LEY-
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ONS

540 Alchymy. Leybourn (W.) Pleasure with Profit, Recreations, Chymical, Magnetical, Astronomical for Ingenious Spirits, *plates and cuts on text*, fine copy, *old calf*, rare 1695



Rev.d T. Newcome

Empt: Dec: 4th: 1694
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# PROPOSALS

FOR THE

Printing of a BOOK

OF

# William Leybourn's,

AUTHOR of the Late

CURSUS MATHEMATICUS,

And of divers other MATHEMATICAL

# TRACTATES:

Who hath now by him, a Miſcellanious Manuſcript ready for the Preſs, which he intends to Entitle,

## Pleaſure with Profit:

It conſiſting of

## RECREATIONS

Of divers Kinds: *Viz.*

| | | |
|---|---|---|
| *Numerical,* | *Aſtronomical,* | *Magnetical,* |
| *Geometrical,* | *Horometrical,* | *Automatical,* |
| *Mechanical,* | *Cryptographical,* | *Chymical,* |
| *Optical,* | *Statical,* | *Hiſtorical,* |

Publiſhed for Ingenious Spirits to make farther Scrutiny into theſe (and the like) Sublime Sciences; and to Divert them from following ſuch Vices, as Youth (in this Age) are too much inclin'd.

THIS Book, when Printed of a good Letter, will contain above *One Hundred* Sheets, with near *Two Hundred* Cutts. And as he hath already Publiſhed his Two laſt Treatiſes, *viz. Dialling, Plain, Concave, Convex, Projective, Reflective, Refractive,* &c. And *Curſus Mathematicus*, by way of Subſcription; he now again offers this to all Lovers of Laudable, Pleaſant, and Profitable Recreations.

And

And to the end that This may come to Publick View in his Life time, he preſents the following Overture ( for the promotion of it ) to all Maſters, Heads, Provoſts, Fellows, Scholars, *&c.* of both Univerſities. ——To all Publick and Private Schoolmaſters, Uſhers and Scholars under them —— To all Gentlemen of Inns of Court or Chancery—— And to all other Private Gentlemen of what Degree ſoever.

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## PROPOSALS as followeth, *viz.*

I. THE Subſcribers to give Thirteen Shillings and Six Pence for each Book in Quires; whereof Six Shillings is to be paid at the time of Subſcription, and Seven Shillings Six Pence at the Delivery of the Book.

II. To Encourage all Perſons that ſhall Contribute to the procuring Subſcriptions for Six Books, ſhall have a Seventh *Gratis.*

III. All who intend to aſſiſt in the Advancement of this Uſeful Work, are deſired to ſend in their Subſcriptions with all ſpeed unto the Perſons here under-named, where Printed Receipts ſhall be given them ; and if they ariſe to any competent number, the Book ſhall be finiſh'd by *Midſummer* next.

The Undertakers are,

**Dorman Newman** at the *King's-Arms* in the *Poultrey.*
**Richard Baldwin** at the *Oxford-Arms* in *Warwick-lane.*
**John Dunton** at the *Raven* in the *Poultrey.*

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## The CONTENTS.

**Recreations.** Numerical, *Treating of*

- NUmbers *in general.*
- Comparative Arithmetick.
- Arithmetical, Geometrical *and* Muſical Proportions.
- *Arithmetical* Theorems.
- *The* Golden Rule, Single *and* Compounded.
- *The* Increaſe *of* Men, Sheep, Swine, Corn, *&c.*
- Changes *in* Bells, Voices, Muſical Inſtruments, Letters, Figures, *&c.*
- *Arithmetical Verſifying, or to make Hexameter and Pentameter Latine Verſes, deduced from five or ſix of the Nine Digits.*
- Enigmatical Problems, *and other* Numerical Devices.

Geometrical,

**Geometrical**, *Consisting of*
- Definitions, *and Practical* Problems.
- Conclusions *performed without* Compasses.
- Longimetria, *or Measuring of* Heights *and* Distances.
- Geodecia, *or Measuring of* Land, *with and without Instrument.*
- Geometrical
  - Arithmetick, *in all its Rules.*
  - Trigonometry, *in all the Cases.*
  - Astronomy, *in several Solar and Astral Principles.*
  - Geography, *in distances of Places.*

**Optical**, *Containing*
- *Several Problems relating to Colours.*
- *Directions how to draw the Figure of any thing, as of Man, a Bird, a Beast,* &c.
- *Choice Perspective Experiments and Conclusions.*

**Astronomical**, *Treating of*
- *A Brief View of the Principles of Astronomy.*
- *The* Circles *of the* Sphere, *and their uses.*
- *The Two Principal* Hypotheses, *viz.* Ptolomean *and* Copernican.
- *Objections against the* Copernican System *briefly answered.*
- *The* Ptolomean System *maintained*; *by* H. P.
- *Some of the strongest Arguments (by way of Objection) the Maintainers of the* Ptolomean System *bring against the* Copernican System; *with the Answers the* Copernicans *give unto them.*
- Eclipses *of the* Sun *and* Moon, *and the* Causes *of them,* &c.
- *Schemes or Types of the Eclipses of the Sun and Moon, both* Ptolomean *and* Copernican.
- *The* Passions, Magnitudes, Motions, Distances *of the* Planets *and* Fixed Stars.
- *General* Rules, *for many good Uses, deduced from the Moons Mean Motion.*
- *The Constellations of Fixed Stars, giving an Account of their* English, Greek, Hebrew, Arabick, Chaldee, Syriack, Persian, Latin, Turkish, &c. *Names*; *and of the principal Stars in each of them*; *and of the* Via Lactea. *And also the Poetical Fables, alluding to these Asterisms*; *shewing how they came to be placed in the Heavens*; *and at what time of the Year any of them will be upon the* Meridian *at Midnight, whereby they may be easily found in the Heavens.*
- *The Rudiments of* Astronomy *put into plain Ryhme*: *By* J. Palmer.

**Horometrical**, *Shewing how*
- *To make* Horizontal, Vertical, *and direct* Reclining Dials *in all Latitudes.*
- Tables *for that purpose.*
- *From an* Horizontal Dial, *to deduce all other* Dials.
- *From a* Point (*or* Gnodus) *placed at all Adventures.*
- *From a* Hole *in a Glass Window.*
- *By help of a* Trigon, *to insert the Equinoctial, Tropicks, and other Signs and Parallels of the Suns Course upon all sorts of Sun-dials*; *also the* Azimuths, Almicanters, *&c.*
- *To make Dials whereby to find the* Hour *by the* Sun *in the Day-time, and by the Stars in the Night.* Stars *several ways.*
- *Of* Instrumental Sun-dials *and* Nocturnals.

**Mechanical**, *Treating of*
- Trochlea, *The* Pulley.
- *The Inclining Plain.*
- Cuneus, *The* Wedge.
- Axis in Peritrochio, *The* Wheel, Crain *and* Capstern.
- Cochlea, *The* Screw.
- Vectis, *The* Leaver.
- Archimedes *his* Cochlea, *or* Water-Screw, *and how a* Perpetual Motion *hath been attempted to be performed thereby.*
- Engines *for moving of* Great *and* Heavy Bodies.
- Engines *of* War *used among the Ancients.*
- Automata *or* Self-movers, *by* Air, Wind, Water *or* Springs.

The

*The* Magnificent Works *of the Ancients.*
*The Time, and Number of Men employed in the Building of some of these Magnificent Works.*
*The Height of several* Obelisks, Steeples, Pyramids, Pillars, *and other* Monuments *in the World, according to our* English *Measure.*
*Such Admirable Pieces of* Work, *as have been made by several Eminent Artists both Ancient and Modern, and some in our present Age.*

Statical, *Treating of*
- *The Art* Statical.
- *The* Ballance.
- *The* Ballance *of* Signeur Galileo Galilei, *for the Discovety of* Mixt Metals, *and of other Irregular Bodies, in respect of* Magnitude *and* Ponderosity.
- *Statical* Theorems.
- *The Comparison of several* Metals *in* Quantity *and* Weight.
- *The* Roman *and* English *Foot.*
- Weights; *and the Ancient* Roman *and our* English *compared.*
- *The* Weight, Worth, Magnitude, *&c. of several* Metals, Waters, *and other* Liquids.
- Foreign Weights *and* Measures *compared with the* English.
- *Statical* Experiments.

Automatical, *Treating of*
- *The making of* Clocks, Watches, *and other* Movements.
- Pendulums, *and their* Vibrations.
- *The* Equation of Time, *and a* Table *thereof.*
- Rules *for the true adjusting, and right managing of* Pendulum Clocks, Watches, *&c.*

Magnetical, *Discoursing of*
- *The* Magnet, *or* Loadstone.
- *The* Attractive *Virtue of the* Load-stone.
- *The* Sympathetical *and* Antipathetical *Property of the* Load-stone.
- *The* Cutting *or* Dividing *of* Load-stones.
- *Finding of the* Poles *of* Load-stones.
- *An* Essay *of a* Perpetual Motion *by* Load-stones.
- Magnetical Inclination.
- Magnetical Experiments.

Cryptographical, *Discovering*
- *Several ways used by the* Ancients *for their secret Conveyances.*
- *Several other ways, for secret Conveyances; as*
  - *By Common Letters of the Alphabet as they are.*
  - *By the Alphabetical Letters transposed.*
  - *By an Astronomical Alphabet.*
  - *By Knots upon a String.*
  - *By Juices, Liquors, &c.*

Chymical, *Discoursing of*
- *Artifical Representations.*
- *Of the* Fire *of* Vestals.
- *The* Philosophers Tree.
- *The* Reanimation *of* Simples.
- *The* Representation *of the* Great World.
- *A* Perpetual Motion.
- *The making of* Gold.
- *Incombustible* Flux.
- Subterraneous Lamps.

Historical, *Treating of*
- *The first* Authors *of divers* Inventions.
- *The* Measures *and Proportions of the* Members *of* Mans Body.
- *Men or* Giants *of Prodigious* Stature.
- Dwarfs, Pigmies, *or* Men *and* Women *of Lower than ordinary* Stature.
- Monsters *and Prodigious* Births.
- *Artificial* Monsters.
- *The* Length *of* Age *which* Men *lived in former Times, shortly after the Creation; and of others of later date.*

# Pleasure with Profit:

Consisting of

# RECREATIONS

OF

## DIVERS KINDS,

VIZ.

| | | |
|---|---|---|
| *Numerical,* | *Astronomical,* | *Automatical,* |
| *Geometrical,* | *Horometrical,* | *Chymical,* |
| *Mechanical,* | *Cryptographical,* | and |
| *Statical,* | *Magnetical,* | *Historical,* |

Published to Recreate Ingenious Spirits; and to induce them to make farther scrutiny into these (and the like) SUBLIME SCIENCES.

AND

To divert them from following such Vices, to which Youth (in this Age) are so much Inclin'd.

By WILLIAM LEYBOURN, Philomathes.

To this Work is also Annext,

## A TREATISE of ALGEBRA,

According to the late Improvements, applied to *Numerical Questions* and *Geometry*; with a NEW SERIES for the speedy *Extraction of Roots*; as also a CONVERGING SERIES for all manner of *Adfected Equations*.

By R. SAULT, Master of the *Mathematical School* in *Adam's*-Court, in *Broad-street*, near the *Royal Exchange*, *LONDON*.

*LONDON:*
Printed for Nathaniel Rolls, at his *Auction House* in *Petty-Cannon-Hall*, near the North side of St. *Paul's* Church. 1695.

# To the INGENIOUS READERS:

## And principally To such as are Mathematically Inclined.

RECREATION, (saith a late Learned Divine) is a second CREATION, when *Weariness* hath almost annihilated our *Spirits*: It is the *breathing* of the *Soul*, which would otherwise be *stifled* with continual *Business*.

And this Interval of *Rest* or *Recreation* produceth the same *Effect*, as well in *Sensitives* and *Vegitives*, as it doth in *Man*: According to that of the *Scholiast*.

*Ager veritanus*, &c.

A *Field* left *Fallow* some few years, will yield
  The Richer *Crop*, when it again is *Till'd*:
A *River* stopped by a *Sluice* a space,
  Runs after *rougher*, and a swifter pace:
A *Bow* a-while *unbent*, will after cast
  Its *Shafts* the *farther*; and them *fix* more *fast*:
A *Soldier* that a season still hath lain,
  Comes with more *fury* to the *Field* again.
    Even so *Man's Body*, while to gather *Breath*,
    From *Rest*, to *Pain* again, it sojourneth:
    It re-collects its *Poars*, and with *Cheer*
    Falls fresh again into its first *Carreer*.

In the Choice of our *Recreations*, we ought to be well satisfied, (1.) In the *Lawfulness* of them. (2.) That they be *Ingenious*: And (3.) That they bear proportion with the *Age*, *Sex* and *Constitution* of *Body* of the *Party* using them: For,

As *Recreations* and *Exercises* (whether of *Body* or *Mind*) are *various*: So one *Dish* of *Meat* may as well please all *Palates*; as one *Recreation* suit all *Dispositions*: And (as I have said elsewhere upon the like occasion), That, although some *Corporeal Exercises* may to some *Bodies* tend more to *Health*, and some *Mental Labours* more to *Wealth*; yet none affords the *Mind* more *pleasure* with less *repentance*, than those of the *Mathematicks* do.

*For instance in a few Corporeal* Exercises; *with* Reflections *upon some of them.*

*Ringing,*] It oft-times makes good *musick* on the *Bells*; but (being a *violent* and *boisterous Exercise*) puts Mens *Bodies* out of *tune*: So that by over-heating of themselves, they have *rung* their own *Passing-bell.*

*Fishing* with the *Angle,*] (an *Exercise* with which Dr. *Whittaker* was much delighted) is a *Recreation* relishing best with some; but to other Dispositions most *distasteful*; and rather a *torture* than a *pleasure*; to stand an whole hour, or more, as *mute* as the *Fish* they hope to take.

*Hunting*] is an *Exercise* most *delightful*, and much in request both with the *Nobility* and *Gentry* of this *Land*; yet *William Cecill*, sometime Lord Treasurer of *England*, took no pleasure in it: For, when some Noble-men had gotten him to ride with them a Hunting, and the *Sport* began to be *cold*; What call you this, says My Lord? Oh! Now, said they, *The Dogs are at a fault*. Yea, quoth the Treasurer, take me again in such a *Fault*, and I'll give you leave to punish me for't.

*Cornelius Agrippa* terms it a most detestable *Recreation*, and vain *Exercise*; a *Pastime* cruel, and totally Tragical: And from the beginning (says he) was the *Exercise* of the *worst* of *men*; for *Cain*, *Lamech*, *Nimrod*, *Ishmael* and *Esau*, were mighty *Hunters*: But in the New Testament we read not of any one that was given thereunto: Yet *Nicholaus* the Third, a *Roman*, and Pope of *Rome*, was so extreamly delighted in *Hunting*, that he inclosed a *Warren* of *Hares* on purpose for his Holiness's *Recreation*.

*Fowling,*] *Ulysses* is said to be the first Inventer thereof; who after the taking of *Troy*, was the first that brought into *Greece Birds* of *Prey* manur'd for *Game*; to comfort with New *Recreations* those that had lost their *Parents* and *Acquaintance* in the

the *Trojan War*: And yet he commanded his Son not to make any use thereof. Notwithstanding this and the foregoing *Exercises* (tho mean and servile in themselves) are now come to be so far esteemed, that the Nobility and Gentry, forsaking other Liberal and Noble Sciences, make these their chief Learning. Mr. *Burton* in his *Melancholy*, tells a Merry Story out of *Poggius* the *Florentine*, condemning the folly of those *Fowlers*; which is this. "A *Physician* of *Millain* (saith he) that "cured *Madmen* and *Idiots*, had a *Pit* of Water in his House, "in which he kept his *Patients*; some up to the *Knees*, some "to the *Girdle*, and some to the *Chin*, *pro modo insaniæ*, as they "were *more* or *less* affected. One of his *Patients*, which was "pretty well recovered, standing at the Physicians Gate, and "seeing a *Gallant* ride by with a *Hawk* on his *Fist*, with his "*Spaniels* after him, would needs know to what use all this "preparation served? the *Gallant* made answer, To kill *Partridges* and other *Fowl*. The Patient demanded again, What "his Fowl might be worth which he killed in a year; he "reply'd, Five or Ten Crowns: And when he urged him further, What his *Hawk*, *Horse* and *Dogs* stood him in? he "told him *Four hundred Crowns*: With that, The Patient bad "him be gone, as he tendred his Life and Safety: For (said "he) if our Master should come and hear you say so, he "would put you into his *Pit* up to the very Chin.

*Shooting with the Long Bow*] is a *Noble Recreation*, and an half *Liberal Art*: There is hardly any comparable to it, for stirring every part of the Body: It openeth the *Breast* and *Pipes*; exerciseth the *Arms* and *Feet* with less violence than *Running*, *Leaping*, and the like. And herein was *Domitian* the Emperor so cunning, that it is reported of him, That let a *Boy* a good distance off hold up his *Hand* against a Wall, and stretch his *Fingers* abroad, he would *shoot* through the *spaces* without touching the *Boys Hand*, or any *Finger* of it. And it is reported of *Domitian* the Emperor, That at two shoots he should fix his Shafts in the Front of Wild Beasts like a Pair of Horns. King *Edward* the Sixth of *England*, with the Long Bow (though he drew no Strong one) shot very well: And once, when *John Dudley*, Duke of *Northumberland*, commended him for *hitting* the *Mark*: *You shot better* (quoth the King) *when you shot off my Good Uncle Protector's Head.*

*Running, Leaping, Dancing* and *Walking*,] are all Excellent *Recreations*, used in the Morning; as we read *Alexander* and

*Epimanondas* did. King *Henry* the Fifth of *England* was ſo ſwift in *running*, that he, with two of his *Nobles* (without *Bow*, or other *Engine*) would take a *Wild Buck* or *Doe* in a large *Park*. Alſo *Harold*, the Son of *Canutus* the Second, was Sirnamed *Harefoot* for his ſwift *running*. And *Ethus*, King of *Scotland*, was of that ſwiftneſs, that he almoſt reached that of *Stags* or *Grayhounds*; and was therefore called *Alipes*, or *Wing'd-foot*. *Philippides* an *Athenian*, in the ſpace of two days, did run 150 *Roman Miles*. And one *Euclides*, another of the ſame Countrey, *went* and *returned* in one day 125 of the like *Miles*.

But thoſe are the beſt *Exerciſes*, which (beſides the refreſhing of the *Body*) enable men to ſome other good Ends: As

*Bowling*,] It teaches Mens *Hands* and *Eyes Mathematical Proportion*: —And (for a Home-Diverſion) the Play at the *Billiard Table* hath not its Peer: It exerciſes the whole *Body moderately*; the *ſtrength* of the *Arm judiciouſly*: It *directs* the *Hand Geometrically*, and the *Eye Optically*: For the attaining to be an Exquiſite Proficient in *playing* at it, depends wholly upon putting in *practice* that *Axiome* of *Euclid* in his *Catoptignes*; which *demonſtrates*, that, *The Angles of Incidence and Reflection are ever more equal*.

*Swimming*] hath ſaved many a man's Life, when himſelf hath been both the *Ship* and the *Cargozoon*. And ſingle Perſons, by their dexterity in this Art, have not ſaved their own Lives only, but their Countrey alſo. For (as *Livie* relates) One *Horatius Cocles*, That, after a long time, he alone, had defended the Bridge over *Tyber* againſt the *Hetruſcans*, the *Romans* brake it down behind him; wherewith, in his *Armour*, he caſt himſelf into the *River*, and (notwithſtanding a *ſhower* of *Darts* and *Arrows* were ſent after him) ſwam with ſafety into the City; which rewarded him with a *Statue* erected in the *Market-place*, and as much *Land* as he could encompaſs with a Plough in one day. —And as reſolute an Attempt was that of *Gerrard* and *Harvey*, two Gentlemen of our own *Nation*, who in the Fight at Sea in 1588. ſwam in the Night-time, and pierced with *Augres*, or ſuch like *Inſtruments*, the ſides of the *Spaniſh Gallions*, and returned back ſafe to the *Engliſh Fleet*. And *Vincent* in his Travails reports, That at *Barlavento*, *Calo* and *Hiſpaniola*, he hath ſeen men ſtay under water the ſpace of three quarters of an Hour; and hath heard of thoſe that would continue an whole Hour.

The forementioned *Exerciſes* are ſuch as are generally uſed,

and

and do tend to the health of Mens *Bodies*; and for the prevention of ſeveral *Maladies* to which by Nature they are inclin'd. But there are other *Corporeal Exerciſes* which are more *Heroical*, and fit only for the *Recreation* of *Princes*, and ſuch *Noble Heroes*, whoſe principal Ambitions tend to the defence of their *King* and *Countrey*: And ſuch are, *Horſemanſhip*, *Tilting*, *Tornamenting*, *Throwing* the *Bar*, *Wreſtling*, &c. Of which inſtances might be given of many *Emperors*, *Kings* and *Generals*, who have performed great *Exploits* thereby. But leaving thoſe of the *Body*, I ſhall proceed to ſuch *Recreations* as adorn the *Mind*; of which thoſe of the *Mathematicks* are inferior to none.

Now the *Excellency* of any *Science* (ſays the Philoſopher) may be judged of, (1.) By the *Excellency* of the *Object*: And (2.) by the *Certainty* of its *Demonſtrations*.

*Firſt*, For the *Object*; It is no leſs than the *whole World*: Not only of the *Terreſtrial*, but the *Cœleſtial* part thereof alſo. So that in this reſpect it far exceeds all thoſe empty and barren Speculations about *Materia Prima*, or *Univerſale*: In the Study of which ſo many do miſpend their Younger Years.

*Secondly*, For the *Demonſtrations* of theſe *Sciences*, they are as infallible as *Truth* it ſelf: And for this reaſon alſo doth it exceed all other *Knowledge* which depend upon *Conjectures* and *Uncertainty*. Since therefore in theſe reſpects, it is one of the moſt *Excellent Sciences* in *Nature*, it may beſt become the Induſtry of *Man*, who is one of the beſt *Works* of *Nature*. And for that end was he made with an *Elevated Aſpect*, with *Head* and *Eyes* exalted: And for what reaſon, the *Poet* tells you.

*Os Homini ſublime dedit, Celumque tueri*
*Juſſit, & erectos ad Sydera tollere vultus.*

God gave to Man an upright Face, that He
Might view the Stars, and learn *Aſtronomy*.

And thus the Kingly Prophet *David*, Pſal. 8. *v.* 3, 4. falls out into this Admiration, *When I conſider the Heavens, the Works of thy Fingers*; *the Moon and the Stars which thou haſt created; What is Man, that thou art mindful of him, and the Son of Man that thou viſiteſt him!* Upon which Text, *Sandys* thus excellently Paraphraſes.

When I pure Heaven, thy Fabrick ſee;
The Moon and Stars, create by Thee

O!

O! what is Man, and his frail Race;
That Thou ſhould'ſt ſuch a ſhadow grace!

Now theſe *Sciences* being ſo excellent in themſelves, and of ſuch benefit to us, we cannot ſpend our leiſure hours better, than in theſe Sublime Sciences. It was ſo with *Julius Cæſar*, who amongſt the Broils and Tumults of the Camp, made choice of this for his *Recreation*: As *Lucan* ſays of him, *Lib.* 10.

*——— Media inter prelia ſemper*
*Stellarum, Cœlique plagis, ſuperiſque vacavit.*

He always leiſure found amidſt his Wars,
To mark the courſe of Heaven, and learn the Stars.

And for this reaſon likewiſe did *Seneca*, amidſt the continual Noiſe and Buſtle of the *Court*, betake himſelf to this Recreation.

*O quam juvabat*, &c.

O what a Pleaſure was it to Survey
Natures *Chief Work*, the *Heavens*! Where we may
View the alternate *Courſes* of the *Sun*,
The Sacred *Chariots*, how the *World* does *run*:
The *Moon's* bright *Orb*, when ſhe's attended by
Thoſe ſcattered *Stars*, whoſe *Light* adorns the *Sky*.

And thus let what I have already ſaid concerning the *Excellency*, *Utility* and *Benefit* of theſe *Mathematical Arts* ſuffice. It may be expected I ſhould ſay ſomething concerning thoſe which I have ſelected in the following *Tractates*: But for that I refer you only to the *Table* of *Contents* following: And for the *uſing* of them, make them as Ballaſt to a *Ship*; to *fix* it, not to *ſtall* it; ſo as to juſtle out its other *Cargo* of *leſs weight*, though of *greater importance* to *Mundane ſubſiſtence*. But I will deter thee (*Reader*) no longer in the *Porch*, but invite thee into the *Inner Rooms*; into which *Ingredere ut Proficias*: And ſo, for this time,

*Farewell.*

The

# The Table of CONTENTS, and Order of the Whole Book.


TRACT. I. Numerical Recreations.

Of Digit, Article, Mixt, Square *and* Cube Numbers, *and some* Observations *upon them.* Pag. 1
*Of* Comparative Arithmetick, *or of the Relation of* Numbers *in* Quantity. 12
*Of* Arithmetical, Geometrical *and* Musical *Proportions.* 14
*Numerical* Theorems. 17
*Concerning the* Golden Rule, *both* Simple *and* Compound. 21
*Of the Increase of* Swine, Corn, Sheep, *&c.* 23
*Of* Changes *in* Bells, Musical Instruments, Voices, *&c.* 29
*Of Numerical* Versifying. 32
*Of Numbers thought upon.* 41
*Numerical* Enigmatical Problems. 33
*Of Extracting the* Square Root *of any Number, without* Multiplication *or* Division. 46
*A most Compendious way of Multiplication.* 50
*Of the Rule of* Ceres *and* Virginum. 51
*Numerical Devices.* 55

TRACT. II. Geometrical Recreations.

Of *Geometrical* Definitions, *and Practical* Problems. Pag. 1
*How (without Compasses) having only a common* Fork, *and a Plain* Rule, *to perform many pleasant* Geometrical Conclusions. 16
Geometrical Arithmetick *in all its Rules.* 28
*Mechanical ways of measuring of Heights, Depths and Distances.* 39
*Of* Altimetria; *or of the Mensuration of* Heights *Accessible or Inaccessible.* 39
Of Longimetria: *Or of the Mensuration of* Distances, *Accessible or Inaccessible.* 41
*Of* Planometria: *Or of the measuring of* Land *Mechanically.* 44
*How to lay down, or make a* Plot *of any piece of* Ground *measured as aforesaid; and to find the* Quantity *thereof in* Acres, Roods *and* Perches. 51
*Of the taking of* Heights, Depths *and* Distances, *accessible or inaccessible; As also of the* Surveying *of* Land *more artificially by* Graduated Instruments. 52
*To make a* Plot, *and to cast up the content thereof.* 66

TRACT. III. Mechanical Recreations.

Of Engines, *by help of which very* Great Weights *may be* raised *with* small strength. Pag. 1
Proclea: *Of the* Pulley. 2
*Of the* Inclining Plain. 3
Cuneus: *Of the* Wedge. 4
*Of the* Crane, Capsten, *or* Wheel. ibid.
Cochlea: *Of the* Wheel. 5
Vectis: *Of the* Leaver. 7
*Of* Archimedes *his* Water-Screw. 9
*From thence a* Perpetual Motion *attempted.* 10
*A Mechanical* Paradox. 12
*Of other* Engines *for the moving of* Heavy Bodies; *and other for* Violent Motions. 14
*Of Engines of* War. 15
*Of* Automata: *Or* Self-Movers. 16
*Of divers* Magnificent Works *of the* Ancients. 20
*The height of several* Obelisks, Steeples, Pyramids *and* Pillars *in the* World, *according to our* English Measure. 23
*Of some such admirable* Pieces of Work *of several kinds, as have been made by* Artists *both* Ancient *and* Modern. 24

TRACT. IV. Statical Recreations.

Of *the Art* Statical. Pag. 1
*Concerning the* Ballance. ibid.
*Statical* Theorems. 3
*Of the* Ballance *of Signeur* Galileo Galilei. 5
*Six Statical* Theorems *of* Archimedes, *taken from his Tractate,* De Incidentibus Aqua. 8
*The Comparison of several* Metals *in* Quantity *and* Weight. 10
*Of the* Roman *and* English Foot. 11
*The Ancient* Roman Weights, *and our* English, *compared.* 12
*The* weight *of* Spheres *of several* Metals *compared.* 13
*Of the* worth, weight, magnitude, *&c. of several* Metals *and* Liquors. 14
*Of the* weight *of* Water *and other things, in* weight *and* magnitude *compared.* 15
*A Comparative* Table *of the* weight *of* Metals, Grains, Liqours, *&c.* 17
*Foreign* Weights *and* Measures *compared with the* English. 18
*Statical* Experiments. 20
*A Postscript.* 23

TRACT. V. Astronomical Recreations.

A *Brief View of* Astronomy. Pag. 1.
*Of a Material* Sphere, *the* Circles *thereof, and the* Use *and* Offices *of them.* 2
*Of the Two Principal* Systems *of the World,* Ptolomean *and* Copernican. 6
*The* Ptolomean *System argued for, and maintained, and the* Copernican *Arguments against it answered.* 8
*The Strongest* Arguments *(by way of* Objection*) the Maintainers of the* Ptolomean System *bring against the* Copernican System: *With the* Answers *the* Copernicans *give unto them.* 21
*Of the* Eclipses *of the Sun and* Moon, *the* Causes *of them; and how, and when they happen.* 26


Types

Types *of the Sun and Moon's* Eclipse *according to* Ptolomy. 28
*A* Type *of the Sun and Moon's* Eclipse *according to* Copernicus. 29
*Of the* Passions *of the* Planets. 30
*The* Rudiments *of* Astronomy, *in plain* Rhyme. 32
*Of the Constellation of the* Fixed Stars; *giving an Account of the* English, Greek, Hebrew, Latin, Arabick, Caldee, Syriack, Turkish, *&c. Names*; *and of the most Eminent* Stars *in each of them*: *With the* Poetical Fables; *declaring how these* Asterisms *came to be placed in the* Heavens; *and also of the* Galaxia. 35

TRACT. VI. Horometrical Recreations.

*TO make an* Horizontal Dial *in any Latitude.* Pag. 1
*Of* North *and* South Dials. 2
*Of* East, West *and* Polar Dials. 3
*Of* Declining Dials. 5
*Of* Dialling *Mechanical.* 8
*Of* Projective Dials. 10
*Of* Reflected Dials. 12
*Mechanically, to inscribe the* Equinoctial Tropicks, *and other* Parallels *of* Declination, *upon all sorts of Sun-Dials*: *And also the* Azimrhs, Almicanters, *&c.* 13
*Of several* Night Dials, *how to* make *and* use *them.* 18
Horometrical Tables *of the* Sun *and* Stars. 21
*Another Mechanical way to make* Reflective *Dials.* 28

TRACT. VII. Crytographical Recreations.

*OF some* Ancient *ways of Secret Conveyance.* Pag. 1
*By the* 24 Letters *of the Common* Alphabet *variously disposed.* 2
*By* Transposition *of the* Alphabet. 7
*By* Astronomical Characters. 9
*By* Knots *tied upon a* String. ibid.
*By a New* Character; *easy to Learn, difficult to decipher*; *and yet Legible by the Motion of the* Fingers. 11
*Other ways of* Secret Writing. 13

TRACT. VIII. Magnetical Recreations.

*OF the* Magnet, *its* Name, *&c.* Pag. 1
*That the whole* Globe *of the* Earth *hath true* Magnetical *Virtue.* 3
*That* Magnetical Virtue *may be infused into* Iron, *without the help of the* Load-stone. 4
*Of the* Attractive *virtue of the* Load-stone. ibid.
*Of the* Sympathy *and* Antipathy *thereof.* 5
*Of the Cutting or* Dividing *of* Load-stones. 6
*To find the* Poles *of a* Load-stone. ibid.
*Of several Attempts that have been made to contrive a* Perpetual motion *by* Magnetical Virtue. 7
*Of* Magnetical Inclination, *and thereby to find the* Latitude *at Sea, or on the Land.* 9

TRACT. IX. Chymical Recreations.

*OF Artificial* Representations. Pag. 1
*Of the* Fire *of* Vestals. 2
*Of the* Philosopher's Tree: *To make it.* ibid.
*Of the Re-animation of* Simples. ibid.
*Of the representation of the* Great World. 3
*Of a famous* Perpetual motion, *invented by* Cornelius Dreble; *and made for K.* James *the First of* England. 4
*Of the making of* Gold. ibid.
*Of the Nature of* Gold. 6
*Of Incumbustible* Flax: *Or a Substance which will not be consumed by* Fire. ibid.
*Of* Subterraneous Lamps. 8

TRACT. X. Automatical Recreations.

*OF the* Nature, *and of the* making *of* Clocks, Watches, *and other* Movements. Pag. 1
*Concerning* Pendulums. 2
*Of finding out fit* Numbers *for* Wheels *and* Pinnions. 5
*Of giving particular* motion *to any* Movement. 8
*To Regulate a true made* Pendulum Clock *or* Watch. ibid.
*A* Table *for the same.* 10
*Its Use.* 11

TRACT. XI. Historical Recreations.

*OF the* Measures *and* Proportions *of the several* Members *of* Man's Body. Pag. 1
*Of* Men, *or* Giants *of Prodigious* Statures. 3
*Of* Dwarfs *and* Pigmies, *&c.* 4
*Of* Monsters, *&c.* 5
*Of the* Length *of* Age *which* Men *lived in former Times, shortly after the* Creation; *and of others of later date.* 10
*Of the First* Authors *of divers famous* Inventions. 13

*THE END.*

## ERRATA.

In Numerical Recreations.

PAge 41. *line* 20. *read* doubled.

In Geometrical Recreations.

*Pag.* 1. *l.* 20. *read* As the. *p.* 41. *l.* 29. r. points E and T. *p.* 15. *l.* 20. *r.* Marks H and L. *p.* 17. *l.* 14. *r.* 2 *c* and 2 *d.* *p.* 23. *l.* 27. *r.* one foot in V. *p.* 24. *l.* 5. *r.* (by Concl. IV.) *p.* 26. *l.* 20. *r.* (by Conclu. III.) *p.* 26. *l.* 33. *r. a* to *e. p.* 26. in the under Scheme M is wanting. *p.* 29. *l.* 16 *r.* erect a Perpendicular. *p.* 29. In the under Scheme P is wanting. *p.* 31. *l.* 43. *r.* points P. and S. *p.* 32. In the uppermost Scheme the Letters C and D are in each other's place. *p.* 37. *l.* 6, *and* 7. *r.* A, B, C and D. *p.* 38. The Letter M is wanting in the Scheme. *p.* 39. *l. ult. r.* 297. 4 inches. *p* 40. *l.* 24. *r.* distance C D. *p.* 43. *l* 32. *r.* as Figure X. *p.* 44. *l.* 3. the line ON. *p.* 44. *l* 5. whereon, *p.* 45. *l.* 13. 75 Links. Ibid. *in several places for* 14.25625. *r.* 16.25625. *p.* 47. in the Scheme 8. 28 is wanting. *p.* 51. *l.* 6. *r. find.* *p.* 59. *l.* 25. *r.* ABCDEFG.

In Mechanical Recreations.

*Pag.* 14. *l. pen. r.* Wheels were augmented. *p.* 15. The Schemes belonging to Sect. 4. in that Page is omitted. *p.* 16. *l.* 22. *r.* Automata. *p.* 28. *l.* 13. r. *The Figure of*

In Statical Recreations.

*Page* 3. *line* 26. *r. Pendency.*

In Astronomical Recreations.

*Page* 35. *line* 22. *read* Galaxia.

In Horometrical Recreations.

*Page* 3. *line* 8. *read* (*viz.* 9, 10, 11 at Night, and 1, 2, 3 in the Morning.) *p* 28. *l.* 14. *r.* Quadrant, or the like. *p.* ibid. *l.* 15. *r.* Day: And being.

In Magnetical Recreations.

*Page* 2. *line* 25. *read* Cynosura. *p.* 4. *l.* 29. *r.* it will there hold it. *p.* 9. *l. ult. r.* in this *Table.*

# Arts and Sciences MATHEMATICAL Professed and Taught by the AUTHOR.

**Arithmetick,**
- In Whole Numbers, and Fractions.
- In Decimals, and by Logarithms.
- Instrumentally, by Decimal Scales, Napiers Bones: And to extract the Square and Cube Roots by Inspection.

**Geometrie:**
- The Principles thereof with the
  - Practice, and
  - Demonstration.

**Astronomie:**
- Theorical and Practical.
- The Description of the Circles of the Sphere.
- The Use of the Globes,
  - Celestial, and
  - Terrestrial.
- To project the Sphere *in Plano* upon any Circle,
  - Right, or
  - Oblique.

## And upon these Foundations, the following Superstructures.

**The Use of Geometrical Instruments, in the Practice of**
- *Longimetria*, or the Mensuration of
  - Heights, Depths, Distances, as of Trees, Towers, &c. Mines, Wells, Descents, &c. Churches, Towers, &c.
- *Planometria*, or the Mensuration of
  - Board, Glass, Pavement, Tiling, &c.
  - Or any other Superficies.
- *Stereometria*, or the Mensuration of
  - Timber, growing or squared.
  - Stone, regular or irregular.
  - Cask, commonly called Gaging.
- *Geodæsia*, or the Measuring of Land divers ways, and by several Instruments; to draw the Plot of a whole Mannor or Lordship; to cast up the Content thereof; and to beautify the same with all necessary Ornaments thereunto belonging.

**Trigonometria:**
- Or, the Mensuration of Triangles, both
  - Plain, and
  - Spherical.
- The Application thereof, in the solution of Problems in
  - Geometry.
  - Astronomy.
  - Geography.
  - Navigation.
  - Fortification.
  - Dialling, &c.

**Navigation:**
- The Principles thereof, and the manner of Sailing by
  - The Plain Sea-Chart.
  - *Mercator*'s Chart.
  - The Arch of a great Circle.

**Horologiographia, Or Dialling:**
- *Arithmetically*, by the Tables of
  - Sines.
  - Tangents.
  - Logarithms.
- *Geometrically*, by
  - Scale, and
  - Compasses.
- *Instrumentally*, by the Sector, Quadrants, Scales, and other Instruments accommodated with Lines for that purpose.

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THE Place of the *Author*'s Residence is about Ten miles from *London* Westward, at a Place called *Southal*, in the Road between *Acton* and *Uxbridge*, and Three miles from *Brainford*: Where he intends to *Read* the *Mathematicks*, and Instruct young Gentlemen, and others: And to Board upon reasonable Terms, all such as shall be pleased to make a more close Application to those Studies: Where such Boarders, and others, (during their time of Residence with him) shall have the Use of all *Books*, *Maps*, *Globes*, and other *Mathematical Instruments*, as are necessary for their *Instruction*, till they provide themselves of such as they shall have occasion for afterwards.

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# Numerical RECREATIONS.

## CHAP. I.

### Of *Digit*, *Article*, *Mixt*, *Square* and *Cube Numbers*; and some *Observations* upon them.

TO pass by the Common *Species* and *Rules* of *Arithmetick*, both *Vulgar* and *Decimal*, in *Whole Numbers* and *Fractions*; as also the *Extraction* of the *Square* and *Cube Roots*; supposing my Reader to be already acquainted with them; I shall proceed to treat of some other *Numerical Practices*, wherein the *Properties* and *Privileges* which some particular *Numbers* have over others; as also in the resolving of several *nigmatical Questions*, to recreate the Spirits of the Ingenious Student in the *Art* of *Numbers*: And I shall begin with the *Nine Digits*, viz. 1, 2, 3, 4, 5, 6, 7, 8, 9.

#### I. *Of the Digit* 1.

The Digit 1 hath a Property which no other Number hath besides it self; for it neither Multiplieth nor Divideth, but leaveth the Number to be so Multiplied or Divided still the same: As if it were required to Multiply 365 by 1, it will still be but 365: Also if you were to Divide 365 by 1, the Quotient will be the same; for 1 may be had 365 times in 365; and 365 Unites that is multiplied by 1, maketh it no more than 365: And from hence it also followeth, that if any Number be divided by 1, there will nothing remain, whereas Numbers divided by any other Digit are liable to.

#### II. *Of the Digit* 2.

If you would multiply readily any number by the Digit 2, it is but doubling of that number; so 365 being doubled makes 730, which is equal to the Product of 365 multiplied by 2. ——Also, if you would divide any number by 2, it is but taking the half of that number; so if 730 were to be divided by 2, the Quotient will be 365, for the half of 730 is 365. ——But this Digit number 2 hath another Property or Privilege above any other Digit, Article, or Mixt Number; for there is no other whole Number to be found, which being added to it self, or

multiplied in it ſelf, that ſhall produce the ſame number ; but 2 added to 2, maketh 4 for the Sum ; and 2 multiplied by 2, produceth 4 for the Product, which is alſo the Rectangle or Square of 2. —— And it is moreover worth the taking notice of, That no Square Number, how large ſoever, can terminate or end with the Digit 2.

### III. *Of the Digit* 3.

If you would multiply any number by 3, to the given number add the double thereof, and the Sum ſhall be equal to the Product ; ſo 365 multiplied by 3, will be 1095 ; for the double of 365 is 730, to which 365 being added, the Sum is 1095 ; and ſo much would 365 multiplied by 3 produce. —— Alſo, to divide any number by 3, take one third part thereof ; ſo one third part of 1095 is 365, which is equal to the Quotient. And with this Digit 3, no Square Number can terminate.

### IV. *Of the Digit* 4.

If you would multiply any number by 4, you muſt double the duplication thereof, and the Sum is the Product ; ſo the double of 365 is 730, which doubled is 1460, and that is the Product of 365 multiplied by 4. ——And if you would divide any number by 4, one fourth part thereof is the Quotient ; ſo one fourth part of 1460 is 365, equal to the Quotient.

### V. *Of the Digit* 5.

If you would multiply any number by 5, add a Cypher to the given number, then the half of that number will be equal to the Product ; ſo 365 multiplied by 5, will produce 1825 ; for if to 365 you add a Cypher, it makes it 3650, the half whereof is 1825, equal to the Product. ——On the contrary, if you would divide any number by 5, double the number, and cut off the laſt figure towards the right hand, (which will always be either a 5 or a Cypher) and the remainder ſhall be the Quotient. ——So if you would divide 1825 by 5, the double of 1825 is 3650, from which cut off the 0 towards the right hand, and it leaves 365, equal to the Quotient.

### VI. *Of the Digit* 6.

If you would multiply any number by 6, add a Cypher to the given number, and take the half thereof, to which add the given number, the Sum ſhall be equal to the Product of that number multiplied by 6 : So if you would multiply 365 by 6, a Cypher added to the given number makes it 3650, the half whereof is 1825, to which 365 added, it makes 2190, equal to the Product of 365 multiplied by 6. —— On the contrary, To divide any number by 6, take half the number, one third part of that half ſhall be the Quotient : So if you would divide 2190 by 6, the half of 2190 is 1095, one third part whereof is 365, equal to the Quotient.

### I. *Observation.*

Between these two last mentioned *Digits* 5 and 6, there is a secret Property; for if you multiply either of them in themselves, the numbers produced by such multiplications shall terminate in themselves; so 5 multiplied in 5, produceth 25; and 6 multiplied in 6 produceth 36, terminating in themselves 5 and 6. —— Also, if any greater numbers be multiplied by 5 or 6, they will continually terminate or end in 5 and 6; so 365 multiplied by 5, produceth 1825, terminating in 5; and 186 multiplied by 6, produceth 1116, terminating in 6.

### II. *Observation.*

The number 6 hath another eminent Property, for all its aliquot parts are equal to himself; as his half (which is 3), his third (which is 2), and his sixth (which is 1), being added together, do make 6. And of Numbers that have this Property, there are but 10 to be found between *One*, and *One Million of Millions*, which are these exhibited in this following Scheme; and in these Numbers you may observe an Order; for every of the Odd Places, as the I, III, V, VII, and IX, do terminate in 6, whose half is 3, an Odd Number; and the Even Places, namely, the II, IV, VI, and VIII, do terminate in 8, the half whereof is 4, an even number. And if you will farther proceed to find more of these numbers, the 20*th.* number having this qualification, will be this, 1511157745155376893 1328.

| | |
|---|---|
| I | 6 |
| II | 28 |
| III | 486 |
| IV | 8128 |
| V | 120816 |
| VI | 2096128 |
| VII | 33550336 |
| VIII | 536854528 |
| IX | 8589869056 |
| X | 137438691328 |

### VII. *Of the Digit* 7.

If you would multiply any number by 7, add a Cypher to the given number, and take the half thereof, to which half add the double of the number given, the Sum of them shall be the Product of the given number multiplied by 7. —— So if you would multiply 365 by 7, add a Cypher to it, and it makes 3650, the half whereof is 1825, to which add 730, the double of 365 the given number, and the Sum will be 2555, which is the Product of 365 multiplied by 7. —— On the contrary, if you would divide any number by 7. ——— Double the number given, and cut off the last figure to the right hand; then take the seventh part of that number and double it, and substract it from the former number, the remainder shall be the Quotient. —— So if you would divide 2555 by 7, that number doubled is 5110, from which cut off the Cypher to the right hand, and it is 511, one seventh part whereof is 73, the double whereof is 146, which substracted from 511, the remainder is 365, and that will be the Quotient of 2555 being divided by 7. —— And with this Digit 7, no Square Number can terminate.

### VIII. *Of the Digit* 8.

To multiply any number by 8, double the number given, and ſubſtract that double from the given number, (a Cypher being added to the given number), that Remainder ſhall be the Product of the given number, multiplied by 8. ——So if you would multiply 365 by 8, the double of 365 is 730, a Cypher added to 365 is 3650, from which ſubſtract the double of 365, namely, 730, and the remainder will be 2920, the Product of 365 multiplied by 8.——In like manner, if you would divide any number by 8, take half the number given ſucceſſively three times, the third half ſhall be the Quotient of the given number divided by 8. ——So if 2920 were a number given to be divided by 8, the half of it is 1460, the half of that is 730, and the half of that is 365, which is the Quotient of 2920 divided by 8. ——And this Digit 8 hath another Property in it, for no Square Number can terminate with it.

### IX. *Of the Digit* 9.

To multiply any number by 9, add a Cypher to the given number, and from that number ſubſtract the given number, the Remainder ſhall be the Product. ——So if you would multiply 365 by 9, add a Cypher to it, it makes 3650, from which ſubſtract 365, and the remainder will be 3285, equal to the Product of 365 being multiplied by 9. ——On the contrary, if you would divide any number by 9, take the third part of the given number twice ſucceſſively, the ſecond remainder ſhall be the Quotient: ——So if you would divide 3285 by 9, one third of 3285 is 1095, and one third of 1095, is 365, which is the Quotient of 3285 divided by 9.

### III. *Obſervation.*

¶ This Digit 9 hath a Privilege above all the other Digits; for if you take any number, the Nines taken out of the groſs ſum of that number, or of all the parts thereof ſeverally, the remaining Digit will be ſtill the ſame: *Example;* In the number 36 there are 4 Nines contained therein; and ſo if you multiply 9 by 4, it will produce 36; and if you take the Nines out of 36, they are four alſo. ——In like manner, if you take the Nines out of this number 248, it is all one as if you ſhould take the Nines out of the ſimple figures 2, 4, and 8, which do make 14, from which 9 being taken, there will remain the Digit 5; and alſo if you divide 248 by 9, the Quotient will be 27, which ſhews that there are 27 times 9 in 248, and the Digit 5 remaining.

### X. *How the Nine* Digits *may be diſpoſed in ſuch* Order, *that the* Number 15 *ſhall be accounted in* Rank, File, *and* Diagonally, 32 *times.*

In the Nine Digits there are Four Even, and Five Odd; now if you ſet the four Even Digits, 2, 4, 6, and 8, at the four corners of a Square, and 5 (which is the middlemoſt of the five odd Digits) in the Center

or

or middle of the Square, as is done in the Margent then between every two even Digits put ſuch an odd Digit as ſhall make the number in that line both in Rank and File 15; as between 2 and 4, put 9, which together make 15, and ſo the reſt; the which 9 Digits thus diſpoſed, 15 may be accounted in *Rank*, *File*, and *Diagonally*, 32 times: Example,

| | Rank | | | |
|---|---|---|---|---|
| | 2 | 9 | 4 | |
| File | 7 | 5 | 3 | File |
| | 6 | 1 | 8 | |
| | Rank | | | |

In Rank,

$$\text{Rank 1.}\left\{\begin{matrix}2&9&4\\4&9&2\\9&2&4\\9&4&2\end{matrix}\right\}\text{equal to 15.}\quad \text{Rank 2.}\left\{\begin{matrix}7&5&3\\3&5&7\\5&7&3\\3&7&5\end{matrix}\right\}\text{equal to 15.}\quad \text{Rank 3.}\left\{\begin{matrix}6&1&8\\8&1&6\\1&6&8\\8&6&1\end{matrix}\right\}\text{equal to 15.}$$

In File,

$$\text{File 1.}\left\{\begin{matrix}2&7&6\\6&7&2\\7&2&6\\6&2&7\end{matrix}\right\}\text{equal to 15.}\quad \text{File 2.}\left\{\begin{matrix}9&5&1\\1&5&9\\5&1&9\\5&9&1\end{matrix}\right\}\text{equal to 15.}\quad \text{File 3.}\left\{\begin{matrix}4&3&8\\8&3&4\\3&4&8\\3&8&4\end{matrix}\right\}\text{equal to 15.}$$

Diagonally,

$$\text{Diagonal Dexter,}\left\{\begin{matrix}2&5&8\\8&5&2\\5&2&8\\5&8&2\end{matrix}\right\}\text{equal to 15.}\quad\Big|\quad \text{Diagonal Siniſter,}\left\{\begin{matrix}4&5&6\\6&5&4\\5&4&6\\4&6&5\end{matrix}\right\}\text{equal to 15.}$$

IV. *Obſervation.*

¶ There is a notable harmony between ſome Numbers, as particularly in theſe two, 220 and 284: For the addition of the Aliquot Parts of the one, do make up the Sum of the other: So

$$\text{The Aliquot Parts of 220 are}\left\{\begin{matrix}110\\55\\44\\22\\20\\11\\10\\5\\4\\2\\1\end{matrix}\right\}\qquad \text{The Aliquot Parts of 284 are,}\left\{\begin{matrix}142\\71\\4\\2\\1\end{matrix}\right\}$$

Whoſe Sum is 284

Whoſe Sum is 220

XI. *Of*

### XI. *Of the* Article Numbers, 10, 100, 1000.

If you would multiply any number by 10, 100, or 1000, *&c.* it is done by adding of ſo many Cyphers towards the right hand of the given number, as there are Cyphers in the Article number by which you are to multiply: So

$$\text{If you are to multiply}\left\{\begin{array}{l}365\\7642\\96421\end{array}\right\}\text{by}\left\{\begin{array}{l}10\\100\\1000\end{array}\right\}\begin{array}{c}\text{the Product}\\\text{will be}\end{array}\left\{\begin{array}{l}3650\\764200\\96421000\end{array}\right.$$

On the contrary, any number may be divided by an *Article Number*, by cutting off from the given number ſo many figures towards the right hand, as there are *Cyphers* in the *Article Number* by which you are to divide: So

$$\text{If you would divide}\left\{\begin{array}{l}7628\\34086\\932073\end{array}\right\}\text{by}\left\{\begin{array}{l}10\\100\\1000\end{array}\right\}\text{the Quotient will be}\left\{\begin{array}{l}762.\frac{8}{10}\\340.\frac{86}{100}\\932.\frac{073}{1000}\end{array}\right.$$

And the like of any other.

### XI. *Of the Numbers* 11, 12, 13, 14, 15, 16, 17, 18, *and* 19.

If you would multiply any number by any of theſe numbers that hath a Unite in the Tenth place, obſerve the method following, where you may ſet down the Product in one ſingle line; as in the Margent;

$$\begin{array}{r}786\\12\\\hline 9432\end{array}$$

Let 786 be a number given to be multiplied by 12; ſet them down as in the Margent, and ſay, Two times 6 is 12; ſet down 2, and keep 1 in mind: ——Then, 2 times 8 is 16, and 1 in mind is 17, and 8 over the 1, is 25; ſet down 5, and bear 2 in mind: Then, 2 times 7 is 14, and 2 in mind is 16, and 8 over 1 is 24: ſet down 4, and bear 2 in mind; which 2 add to the laſt figure 7, it makes 9; ſo that 786 multiplied by 12, produces 9432. And ſo of others; as in Examples,

$$\begin{array}{r}4264\\16\\\hline 68224\end{array}\qquad\qquad\begin{array}{r}60304\\19\\\hline 1145776\end{array}$$

XII. *Of*

## XII. *Of* Square *and* Cube *Numbers.*

It is obſerved before, that no Square Number, can terminate in any of theſe four Digits 2, 3, 7, or 8: Notwithſtanding, there are many ſubtle Properties in Square Numbers: As,

1. If from an Unite you do ſucceſſively add the next odd digit number, the ſum of thoſe two Numbers ſhall produce Square Numbers: As, if to 1 you add 3, the next odd number, the Sum is 4, a Square Number; to which if you add 5, the next odd Digit, it makes 9, a Square Number; to which if you add 7, the next odd Digit, it makes 16, a Square Number; and ſo on, as in this little Table.

| | | | | | |
|---|---|---|---|---|---|
| For | 1 | and | 3 | makes | 4 | A Square Number. |
| | 4 | | 5 | | 9 | |
| | 9 | | 7 | | 16 | |
| | 16 | | 9 | | 25 | |
| | 25 | | 11 | | 36 | |
| | 36 | | 13 | | 49 | |
| | 49 | | 15 | | 64 | |
| | 64 | | 17 | | 81 | |
| | 81 | | 19 | | 100 | |

2. If a Series of Eleven Square Numbers be orderly ſet one under another, the terminating figure of the firſt, and the terminating figure of the laſt ſhall be the ſame. And ſo if the terminating figure of the firſt number be a Cypher, the ſecond ſhall be 1, the third 4, the fourth 9, the fifth 6, the ſixth (or middlemoſt) 5, the ſeventh 6, the eighth 9, the ninth 4, the tenth 1, the eleventh 0, as in this Table. So likewiſe if Cube Numbers be ſucceſſively added from Unity, thoſe Numbers ſhall alſo be Square Numbers.

| Roots | Squares |
|---|---|
| 80 | 6400 |
| 81 | 6561 |
| 82 | 6724 |
| 83 | 6889 |
| 84 | 7056 |
| 85 | 7225 |
| 86 | 7396 |
| 87 | 7569 |
| 88 | 7744 |
| 89 | 7921 |
| 90 | 8100 |

## XIII.

*A Table of the Nine Digits, each of them being Multiplied into all the Nine Digits, and the several Products of those Multiplications Added.*

| I. | | | |
|---|---|---|---|
| 1 | 1 | 1 | 1 |
| 2 | 1 | 2 | 2 |
| 3 | 1 | 3 | 3 |
| 4 | 1 | 4 | 4 |
| 5 | 1 | 5 | 5 |
| 6 | 1 | 6 | 6 |
| 7 | 1 | 7 | 7 |
| 8 | 1 | 8 | 8 |
| 9 | 1 | 9 | 9 |
| | | 45 | 45 |

| II. | | | |
|---|---|---|---|
| 1 | 2 | 2 | 2 |
| 2 | 2 | 4 | 4 |
| 3 | 2 | 6 | 6 |
| 4 | 2 | 8 | 8 |
| 5 | 2 | 10 | 1 |
| 6 | 2 | 12 | 3 |
| 7 | 2 | 14 | 5 |
| 8 | 2 | 16 | 7 |
| 9 | 2 | 18 | 9 |
| | | 90 | 45 |

| III. | | | |
|---|---|---|---|
| 1 | 3 | 3 | 3 |
| 2 | 3 | 6 | 6 |
| 3 | 3 | 9 | 9 |
| 4 | 3 | 12 | 3 |
| 5 | 3 | 15 | 6 |
| 6 | 3 | 18 | 9 |
| 7 | 3 | 21 | 3 |
| 8 | 3 | 24 | 6 |
| 9 | 3 | 27 | 9 |
| | | 45 | 54 |

| IV. | | | |
|---|---|---|---|
| 1 | 4 | 4 | 4 |
| 2 | 4 | 8 | 8 |
| 3 | 4 | 12 | 3 |
| 4 | 4 | 16 | 7 |
| 5 | 4 | 20 | 2 |
| 6 | 4 | 24 | 6 |
| 7 | 4 | 28 | 1 |
| 8 | 4 | 32 | 5 |
| 9 | 4 | 36 | 9 |
| | | 180 | 45 |

| V. | | | |
|---|---|---|---|
| 1 | 5 | 5 | 5 |
| 2 | 5 | 10 | 1 |
| 3 | 5 | 15 | 6 |
| 4 | 5 | 20 | 2 |
| 5 | 5 | 25 | 7 |
| 6 | 5 | 30 | 3 |
| 7 | 5 | 35 | 8 |
| 8 | 5 | 40 | 4 |
| 9 | 5 | 45 | 9 |
| | | 225 | 45 |

| VI. | | | |
|---|---|---|---|
| 1 | 6 | 6 | 6 |
| 2 | 6 | 12 | 3 |
| 3 | 6 | 18 | 9 |
| 4 | 6 | 24 | 6 |
| 5 | 6 | 30 | 3 |
| 6 | 6 | 36 | 9 |
| 7 | 6 | 42 | 6 |
| 8 | 6 | 48 | 3 |
| 9 | 6 | 54 | 9 |
| | | 270 | 54 |

| VII. | | | |
|---|---|---|---|
| 1 | 7 | 7 | 7 |
| 2 | 7 | 14 | 5 |
| 3 | 7 | 21 | 3 |
| 4 | 7 | 28 | 1 |
| 5 | 7 | 35 | 8 |
| 6 | 7 | 42 | 6 |
| 7 | 7 | 49 | 3 |
| 8 | 7 | 56 | 1 |
| 9 | 7 | 63 | 9 |
| | | 315 | 43 |

| VIII. | | | |
|---|---|---|---|
| 1 | 8 | 8 | 8 |
| 2 | 8 | 16 | 7 |
| 3 | 8 | 24 | 6 |
| 4 | 8 | 32 | 5 |
| 5 | 8 | 40 | 4 |
| 6 | 8 | 48 | 2 |
| 7 | 8 | 56 | 1 |
| 8 | 8 | 64 | 0 |
| 9 | 8 | 72 | 9 |
| | | 360 | 42 |

| IX. | | | |
|---|---|---|---|
| 1 | 9 | 9 | 9 |
| 2 | 9 | 18 | 9 |
| 3 | 9 | 27 | 9 |
| 4 | 9 | 36 | 9 |
| 5 | 9 | 45 | 9 |
| 6 | 9 | 54 | 9 |
| 7 | 9 | 63 | 9 |
| 8 | 9 | 72 | 9 |
| 9 | 9 | 81 | 9 |
| | | 405 | 81 |

CHAP.

## XIV. *Some Remarks upon the Nine Digits, as they are disposed in the Table.*

### I. *Of the Digit* 1.

LIttle can be ſaid concerning this *Digit*, for that it neither Multiplieth nor Divideth, but leaveth the Number which is Multiplied or Divided ſtill the ſame: But this you may take notice of, That any two Terms, taken equidiſtant from the Middle Term, do make 10, and the Middle Term (which is 5) doubled does make 10 alſo.

So the $\left\{\begin{matrix}1\\2\\3\\4\end{matrix}\right.$ and $\left.\begin{matrix}9\\8\\6\\5\end{matrix}\right\}$ are every of them equal to 10.

Again; If you Multiply the laſt term (9) by the middlemoſt term (5), that Product ſhall be equal to the Sum of all the Products added together; for 1, 2, 3, 4, 5, 6, 7, 8, and 9, added together, do make 45.

Alſo, If you leave out the laſt term (9), and take the two extreams ſucceſſively, and add them together, every of their Sums ſhall be equal to 9.

As $\left\{\begin{matrix}8\\7\\6\\5\end{matrix}\right.$ and $\left.\begin{matrix}1\\2\\3\\4\end{matrix}\right\}$ are all of them equal to 9.

### II. *Of the Digit* 2.

In the Addition of the Products of the Multiplication of this *Digit*, you have one of every of the Nine Digits, tho not orderly diſpoſed, yet they ſtand ſo, that if you add the two extreme terms equidiſtant from the middle term together, the Sum of each of them ſhall be equal to (11).

So $\left\{\begin{matrix}9\\8\\7\\6\end{matrix}\right.$ and $\left.\begin{matrix}2\\3\\4\\5\end{matrix}\right\}$ are each of them equal to 11.

And if you leave out the laſt term 9, then every two extream terms taken together, ſhall be equal to (9) the laſt term.

As $\left\{\begin{matrix}2\\4\\6\\8\end{matrix}\right.$ and $\left.\begin{matrix}7\\5\\3\\1\end{matrix}\right\}$ each equal to 9.

And again, If you add the numbers in the fourth row under this Digit together, you will find the Sum of them to be 45, which multiplied

by the Digit ( 2 ) makes 90, equal to the Sum of the Products of all the Multiplications of this Digit, which ſtand in the third *Row* under Digit II.

### III. *Of the Digit* 3.

In this *Digit* you may obſerve (as in all the reſt) that the Products of the ſeveral Multiplications do proceed in an *Arithmetical Progreſſion*, the Common Difference being that of the *Digit*: So in this of the *Digit* (3). Wherefore if you add any two terms equidiſtant from the middle term, the Sum of thoſe two terms ſhall be equal, and the double of the middle term equal thereunto alſo: So in this

| | | | |
|---|---|---|---|
| 3 | | 27 | |
| 6 | | 24 | |
| 9 | and | 21 | are all equal to 30. |
| 12 | | 18 | |
| 15 doubled | | | |

In this Digit you may obſerve, that all the Additions of the Products are one of theſe three *Digits*, viz. 3, 6, or 9; and now if you multiply every one of theſe ſeverally by (3) the common difference, the Products of each of them will be 9, 18, 27; which added together do make 54, which is equal to the Sum of the fourth Row under this Digit (3). And in this fourth Row of Additions, if you add the two extream terms, as 3 and 9 togeter, their Sum will be 12, to which the middle term (6) doubled, is alſo equal.

### IV. *Of the Digit* 4.

In the fourth Row under this Digit (4) you have all the 9 Digits produced; and if you omit the laſt term, every two of the reſt added together ſhall be equal to 9; and the Sum of all that Row added together makes 45; which if you multiply by the digit (4), the Product will be (180) equal to the third Row of all the Products added together.

### V. *Of the Digit* 5.

This Digit hath all the Nine Digits in the fourth Row of Additions (as the Firſt, Second, and Fourth had), and therefore hath the ſame qualifications; for omitting the laſt term, every two figures taken equidiſtant from the extreams, ſhall be equal to (9), and the Sum of all that Row ſhall be (45); which multiplied by the common difference (5) the Product ſhall be (225) equal to the Sum of all the Products of the Multiplications in the third Row. In which Row alſo, if you add the two extream terms together (5 and 45), the Sum of them is (50), and is equal to the double of the middle term (25) And ſo alſo in the fourth Row, if you add the two extream Digits (9 and 5) together, their Sum (14) ſhall be equal to the double of the middle term (7).

VI. *Of*

## VI. *Of the Digit 6.*

This Digit hath the ſame qualifications as had the Digit (3), for all the fourth Row of Additions are one of theſe Digits 6, 3, or 9: And omitting the laſt term, every two terms taken equidiſtant from the extreams, ſhall be equal to 9, and the ſum of all of them equal to 54, equal to the laſt number of the third row: And in the third row, if you add any two numbers equidiſtant from the two extreams, their ſum will be 60, equal to the double of the middle term (30). And farther; the ſum of the fourth row being (54), that multiplied by (5), a number leſs by one than (6) the common difference, (becauſe it exceeds 5), the Product will be 270, equal to the ſum of all the Products in the third row.

## VII. *Of the Digit 7.*

In this Digit (as in all the reſt) the third row, which proceeds by multiplying of the Digit 7 into all the other Digits, deſcends in Arithmetical Progreſſion, the common difference being (7); and ſo if you add the two extream numbers together, as (7) and (63), the ſum of them will be (70), which will be equal to the double of the middle number (35). And the like will be by the addition of any two of them equidiſtant from the two extreams, or from the middle number,

$$\text{As}\left\{\begin{matrix}14 & & 56\\ 21 & \text{and} & 49\\ 28 & & 42\end{matrix}\right\}\text{ are all of them equal to 70.}$$

And ſo is the double of (35 the middle term alſo) equal to 70.

Again; the laſt number in the third being (63) multiply it by (5), a number leſs by 2 than the common difference, and the Product will be (315) equal to the ſum of all the Products in that third row added together.

## VIII. *Of the Digit 8.*

In this the third Row increaſes by an Arithmetical Progreſſion, the common difference being (8); ſo that the two extream terms (8 and 72) being added together, do make (80), equal to the double of the middle term (40), and ſo any two that are equidiſtant from the middle term: And for the ſum of them, multiply the laſt term (72) by (5) and the Product will be (360) equal to the ſum of all the Products in the third row: And for the fourth row, they all deſcend till they come to (0) the laſt being (9) as it is in all the other Unites.

## IX. *Of the Digit 9.*

The third row under this Digit proceeds in an Arithmetical Progreſſion, ſo that the two extream terms (8 and 81) make (90), equal to the double of (45) the middle term; and ſo do any two of the reſt that are taken equidiſtant from both the extreams, or from the middle

term (45): And for the ſum of the numbers in this third row, the laſt number (81) multiplied by (5) gives (405) for the ſum of all that row. As for the numbers (or Sums) in the fourth row, they are all equal one to the other, namely (9), and they being all added together, their ſum is equal to the laſt term in the third row.

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# CHAP. II.

## *Of Comparative* Arithmetick; *or of the Relation of Numbers in* Quantity.

COmparative *Arithmetick* is performed by Numbers, as they are conſidered to have relation one to another in *Quantity* or *Quality*.

1. *Relation in Quantity* ] is the reference or reſpect that the Numbers themſelves have one to another: As when the compariſon is made between 6 and 2, or 2 and 6; —— 5 and 3, or 3 and 5. And here the numbers propounded are always two, whereof the firſt is called the *Antecedent*, and the ſecond the *Conſequent*; ſo in the firſt *Example* 6 is the *Antecedent*, and 2 the *Conſequent*; and in the ſecond, 2 is the *Antecedent*, and 6 the *Conſequent*.

2. *Relation in Quality* ], conſiſts either in the *Difference*, or elſe in the *Rate* or *Reaſon* that is found between the Terms propounded.

3. *Difference.* ] The *Difference* of two numbers is the remainder which is left after Subtraction of the leſſer out of the greater; ſo 6 and 2 being the Terms propounded, 4 is the *Difference* between them, for 2 ſubtracted from 6, the remainder is 4.

4. *Rate* or *Reaſon.* ] The *Rate* or *Reaſon* between two numbers, is the *Quotient* of the Antecedent divided by the Conſequent: So if it be demanded what *Rate* or *Reaſon* 6 hath to 2; the Anſwer is, *Triple Reaſon*; for if you divide the Antecedent 6, by the Conſequent 2, the Quotient will be 3, 2 being contained in 6 juſt three times. ——In like manner is there ſub-triple Reaſon between 2 and 6; for if you divide 2 by 6, the Quotient is $\frac{2}{6}$, or $\frac{1}{3}$, becauſe 6 being not found once in 2, there remains 2 for Numerator, 6 the Diviſor being the Denominator. This *Rate* or *Reaſon* of Numbers is either *Equal*, or *Unequal*.

5. *Equal Reaſon* ] Is the relation that equal numbers have one to another, as 5 to 5,——6 to 6,———7 to 7, *&c.* For here, one being divided by the other, the Quotient is always an Unite; for if it be demanded, how often 5 may be had in 5, the anſwer will be, 1, or Unity.

6. *Unequal Reaſon* ] is the relation that unequal numbers have one unto another; and this is either of the *Greater* to the *Leſſer*, or of the *Leſs* to the *Greater*. ———*Unequal Reaſon of the Greater to the Leſſer* ], is, when the greater term is Antecedent, as of 6 to 2, or 9 to 7, and the like; for here the Quotient of the Antecedent divided by the Conſequent, is always greater than Unity; ſo 6 divided by 2, the Quotient is 3, and 9 divided by 7, is $1\frac{2}{7}$. ———But *Unequal Reaſon of the Leſſer to the Greater* ], is, when the leſſer term is Antecedent, as of 2 to 6, or 7 to 9, *&c.* ——— And here the Quotient of the Antecedeut divided by the

the Consequent, is always less than Unity; so 2 divided by 6, the Quotient is $\frac{2}{6}$, or $\frac{1}{3}$, and 7 divided by 9, is $\frac{7}{9}$

Each of these kinds of *Unequal Reason* is again subdivided into Five other kinds or varieties; whereof the three first are *Simple*, and the other two are *Mixt.* ——The Simple kinds of *Unequal Reason* are, (1.) *Manifold.* (2.) *Superparticular.* (3.) *Superpartient.*

7. *Manifold Reason of the Greater to the Less* ], is when the Consequent is contained in the Antecedent divers times, without any part remaining; as 4 to 2, 8 to 4, 16 to 8; which is called Double *Reason*, because the Less is contained twice in the Greater; so 6 to 2 is *Triple Reason*, and 8 to 2 *Fourfold Reason*, &c. And here, the Quotient of the Antecedent divided by the Consequent, is always a whole number; as 8 divided by 2, the Quotient is 4, a whole number. ——The opposite of this kind, *viz.* Of the *Less* to the *Greater*, is called *Sub-manifold*: Examples hereof are, 2 to 4, 4 to 8, 8 to 16, &c. Also 2 to 6, 2 to 8, 2 to 10, &c.

8: *Superparticular Reason of the Greater to the Lesser* ], is, when the Antecedent contains the Consequent once; and besides, an Aliquot part of the Consequent; that is, one half, one third, one fourth, or one fifth, &c. of the Consequent; as 3 to 2, 4 to 3, 5 to 4, 6 to 5, and the like: So here, 3 divided by 2, the Quotient is $1\frac{1}{2}$; and 4 divided by 3, the Quotient is $1\frac{1}{4}$; 5 by 4 the Quotient is $1\frac{1}{5}$; wherefore I say, 2 and half 2 (which is 1) do constitute 3; so 3, and $\frac{1}{3}$ of 3 do constitute 4; and so of the rest. —— For here, the Quotient of the Antecedent divided by the Consequent, is a Mixt Number, whose whole part, and the Numerator of the Fraction, is always an Unite. ——The opposite Reason of this kind is *Subsuperparticular*, as 2 to 3, 3 to 4, 4 to 5, 5 to 6, &c.

9. *Superpartient of the Greater to the Less* ], is, when the Antecedent contains the Consequent once, and divers parts of the Consequent besides; as 5 to 3, 7 to 5, 7 to 4, 8 to 5, 9 to 5, 11 to 7, &c. Here 5 divided by 3, the Quotient is $1\frac{2}{3}$, and therefore 5 contains 3 once, and $\frac{2}{3}$ of 3, which is 2, and they two together do constitute 5. ——Here the Quotient of the Antecedent divided by the Consequent, is a *Mixt Number*, whose whole part being a Unite, hath always for the Numerator of the Fraction a Number composed of more Unites than one; so the conference being made between 5 and 3, and 5 the Antecedent being divided by 3 the Consequent, the Quotient is $1\frac{2}{3}$. ——The opposite of this Reason is *Subsuperpartient*; Examples hereof are, 3 to 5, 5 to 7, 4 to 7, 5 to 8, 5 to 9, 7 to 11, &c.

The Mixt kinds of *Unequal Reason* are two, *viz.* (1.) *Manifold Superparticular.* And (2.) *Manifold Superpartient.*

10. *Manifold Superparticular Reason* ], is, when the Antecedent contains the Consequent divers times, and an *Aliquot part* of the Consequent besides; as 5 to 2, 10 to 3, 17 to 4, 21 to 5, and the like. ——Here the Quotient of the Antecedent divided by the Consequent, is a Mixt Number, whose whole part consisting of more Unites than one, hath always an Unite for the Numerator of the Fraction annexed unto it; so 5 divided by 2, hath for the Quotient $2\frac{1}{2}$, and 21 divided by 5, the Quotient

ent is $4\frac{1}{3}$. —— And the oppoſite of this Reaſon is *Submanifold Superparticular*; as 2 to 5, 2 to 7, 3 to 7, 4 to 9, *&c.*

11. *Manifold Superpartient Reaſon* ], is, when the Antecedent contains the Conſequent divers times; and divers parts of the Conſequent beſides; as 8 to 3, 17 to 5, 19 to 4, 28 to 5, *&c.* — Here the Quotient of the Antecedent divided by the Conſequent, is a Mixt Number, whoſe whole part, as alſo the Numerator of the Fraction annexed unto it, is always a number compoſed of more Unites than one: —— So 8 divided by 3, the quotient is $2\frac{2}{3}$, and 28 by 5, the quotient is $5\frac{3}{5}$, *&c.* — And the oppoſite hereof is *Submanifold Superpartition*; as 3 to 8, 5 to 17, 4 to 19, 5 to 28, and the like.

These are the ſeveral *Varieties* of the *Rates* or *Reaſons* that are found among *Numbers*; ſo that no two *Numbers* can be named, but the *Rate* or *Reaſon* between them is comprehended under one of theſe laſt Five Heads.

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# CHAP. III.

## *Of* Arithmetical, Geometrical, *and* Muſical *Proportions.*

### I. *Of Arithmetical Proportion.*

ARithmetical Proportion (or Habitude) is an equality of *Differences*: That is to ſay, when ſeveral Numbers have one and the ſame *Difference*: And this Habitude is twofold, *viz.* (1.) *Continued.* (2.) *Diſcontinued.*

1. *Arithmetical Proportion Continued* ], is, when of ſeveral Numbers, the Second exceedeth the Firſt, by the ſame number of Unites, as the Third exceeds the Second, and as the Fourth doth the Third; and ſo *in infinitum.*

As thus,

1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, *&c.* do differ from each other by (1), or One Unite. And 1, 3, 5, 7, 9, *&c.* differ by (2) or Two Unites. Alſo 1, 6, 11, 16, 21, 26, *&c.* differ by (5) or Five Unites. And this Orderly proceeding of Numbers from the leſſer to the greater, is that which we properly call *Arithmetical Progreſſion.*

2. *Arithmetical Proportion Diſcontinued* ], is, when the Second Number exceeds the Firſt, by the ſame number of Unites as the Fourth doth the Third; but not as the Third doth the Second.

As for Example;

1, 3, 7, 9, are four diſtinct *Arithmetical Proportionals Diſcontinued.* —— For 3 exceeds 1 by the ſame number of Unites (*viz.* 2.) as 9 exceeds 7, but not as 7 doth 3. —— So again, 2, 7, 10, 15, are four *Arithmetical Proportionals Diſcontinued*; for 7 exceedeth 2 by (5), and ſo doth 15 exceed 10; but 10 doth not exceed 7 by (5), but by (3). And this is *Arithmetical Proportion Diſcontinued.*

II. *Of*

## II. *Of Geometrical Proportion.*

*Geometrical Proportion, or Habitude,*] is the equality of *Ratio's*; or it is that which shews what part or parts one Number is of another: ——Or more plainly thus; It is an Increase by a *Common Multiplication.*

So these Numbers, 1, 2, 4, 8, 16, 32, 64, *&c.* are Numbers in *Geometrical Proportion.* where the *Common Multiplier* is [2], that is, the first multiplied by 2, produceth the second; the second multiplied by 2, produceth the third, and so on *in infinitum.* ———Or in these Numbers, 3, 9, 27, 81, 243, *&c.* where the *Common Multiplier* is [3.] And this is called *Geometrical Progression.*

Of both these kinds of Progression I have inserted Tables.

*Arithmetical Progression, the Common Difference being*

| One | Two | Three | Four | Five | Six | Seven | Eight | Nine | Ten |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 |
| 3 | 6 | 9 | 12 | 15 | 18 | 21 | 24 | 27 | 30 |
| 4 | 8 | 12 | 16 | 20 | 24 | 28 | 32 | 36 | 40 |
| 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 |
| 6 | 12 | 18 | 24 | 30 | 36 | 42 | 48 | 54 | 60 |
| 7 | 14 | 21 | 28 | 35 | 42 | 49 | 56 | 63 | 70 |
| 8 | 16 | 24 | 32 | 40 | 48 | 56 | 64 | 72 | 80 |
| 9 | 18 | 27 | 36 | 45 | 54 | 63 | 72 | 81 | 90 |
| 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 |
| 11 | 22 | 33 | 44 | 55 | 66 | 77 | 88 | 99 | 110 |
| 12 | 24 | 36 | 48 | 60 | 72 | 84 | 96 | 108 | 120 |
| 13 | 26 | 39 | 52 | 65 | 78 | 91 | 104 | 117 | 130 |
| 14 | 28 | 42 | 56 | 70 | 84 | 98 | 112 | 126 | 140 |
| 15 | 30 | 45 | 60 | 75 | 90 | 105 | 120 | 135 | 150 |
| 16 | 32 | 48 | 64 | 80 | 96 | 112 | 128 | 144 | 160 |
| 17 | 34 | 51 | 68 | 85 | 102 | 119 | 136 | 153 | 170 |
| 18 | 36 | 54 | 72 | 90 | 108 | 126 | 144 | 162 | 180 |
| 19 | 38 | 57 | 76 | 95 | 114 | 133 | 152 | 171 | 190 |
| 20 | 40 | 60 | 80 | 100 | 120 | 140 | 160 | 180 | 200 |
| 21 | 42 | 63 | 84 | 105 | 126 | 147 | 168 | 189 | 210 |
| 22 | 44 | 66 | 88 | 110 | 132 | 154 | 176 | 198 | 220 |
| 23 | 46 | 69 | 92 | 115 | 138 | 161 | 184 | 207 | 230 |
| 24 | 48 | 72 | 96 | 120 | 144 | 168 | 192 | 216 | 240 |
| 25 | 50 | 75 | 100 | 125 | 150 | 175 | 200 | 225 | 250 |

## *Geometrical Progression.*

| | | |
|---|---|---|
| 1 | 1 | 1 |
| 2 | 3 | 4 |
| 4 | 9 | 16 |
| 8 | 27 | 64 |
| 16 | 81 | 256 |
| 32 | 243 | 1,024 |
| 64 | 729 | 4,096 |
| 128 | 2,187 | 16,384 |
| 256 | 6,561 | 65,536 |
| 512 | 19,683 | 262,144 |
| 1 | 1 | 1 |
| 5 | 6 | 7 |
| 25 | 36 | 49 |
| 125 | 216 | 343 |
| 625 | 1,296 | 2,401 |
| 3,125 | 7,756 | 16,807 |
| 15,625 | 46,536 | 117,649 |
| 78,125 | 279,216 | 823,543 |
| 390,625 | 1,675,296 | 5,764,801 |
| 1,953,125 | 10,651,776 | 40,353,607 |
| 1 | 1 | 1 |
| 8 | 9 | 10 |
| 64 | 81 | 100 |
| 512 | 729 | 1,000 |
| 4,096 | 6,561 | 10,000 |
| 32,768 | 59,049 | 100,000 |
| 262,144 | 531,441 | 1,000,000 |
| 2,097,152 | 4,782,969 | 10,000,000 |
| 16,777,216 | 43,046,721 | 100,000,000 |
| 134,217,728 | 387,420,489 | 1,000,000,000 |

| *Geometrical Progression.* | *Arithmetical Progression.* |
|---|---|
| 10 | 1 |
| 100 | 2 |
| 1,000 | 3 |
| 10,000 | 4 |
| 100,000 | 5 |
| 1,000,000 | 6 |
| 10,000.000 | 7 |
| 100,000,000 | 8 |
| 1,000,000,000 | 9 |
| 10,000,000,000 | 10 |
| 100,000,000,000 | 11 |
| 1,000,000,000,000 | 12 |
| 10,000,000,000,000 | 13 |
| 100,000,000,000,000 | 14 |
| 1,000,000,000,000,000 | 15 |
| 10,000,000,000,000,000 | 16 |
| 100,000,000,000,000,000 | 17 |
| 1,000,000,000,000,000,000 | 18 |
| 10,000,000,000,000,000,000 | 19 |
| 100,000,000,000,000,000,000 | 20 |
| 1,000,000,000,000,000,000,000 | 21 |
| 10,000,000,000,000,000,000,000 | 22 |
| 100,000 ,000,000,000,000,000,000 | 23 |
| 1,000,000,000,000,000,000,000,000 | 24 |
| 10,000,000,000,000,000,000,000,000 | 25 |

In

In this *Progreſſion* it is viſible, how *Addition* and *Subtraction* in *Arithmetical Progreſſion*, anſwers to *Multiplication* and *Diviſion* in *Geometrical Progreſſion*. —— For, As in *Geometrical Progreſſion*, 1000 multiplied by 100,000, produces 100,000,000: So in *Arithmetical Progreſſion*, the numbers anſwering to 1000, and 100,000, are (3) and (5,) which being added together make (8,) which anſwers to this Product 100,000,000. ——And again, As in *Geometrical Progreſſion* (100,000,000) being *divided* by (100,000) the *Quotient* is (1000.) So in *Arithmetical Progreſſion*, If from the correſpondent number, belonging to the former *Product* 100,000,000, (*viz.* 8,) you ſubtract any of the other correſpondent numbers, *viz.* (5,) the remainder will be the other correſpondent number (*viz.* 3,) which anſwers to 1000.

### III. *Of Muſical Proportion.*

*Muſical Proportion or Habitude,*] is, when the firſt number hath the ſame proportion to the third, which the difference between the firſt and ſecond hath to the difference between the ſecond and the third.

As in theſe numbers [3, 4, 6,] whereas 3 is the half of 6: So 1, which is the difference between 3 and 4 the half of 2.

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## CHAP. IV.

## Numerical Theorems.

I. *If* Numbers *(how many ſoever) exceed one another by an equal* Interval; *the* Interval *between the* Greateſt *and the* Leaſt, *is* Multiplex *of that equal* Interval: *according to the multitude of the Numbers propounded, leſs by* One.

LET the numbers propoſed be theſe four 1, 3, 5, 7, whoſe common *Interval* is 2. Then (by the *Hypotheſis*) 6 is the *Interval* between the *Greateſt* 7, and the *Leaſt* 1. ——And likewiſe the three numbers 2, 2, 2, are every of them equal to the *common difference*, and equal one to the other. And the multitude of them (*viz.* three) equal to the multitude of the number given, (*viz.* four) leſs by *One*. —And laſtly, The *Aggregate* of theſe three numbers (*viz.* ſix) is equal to the Interval between 7 the *Greateſt*, and 1 the *Leaſt*, viz. 6.

II. *If* Numbers (*how many ſoever*) *contain the one the other by an equal* Ratio, *then the* Greateſt *of thoſe* Numbers, *is* Multiplex *of the* Powers *of the Denomination of that equal* Ratio *multiplied by the* Leaſt; *according to the Multitude of the Numbers* given, leſs by One.

LET the *Numbers* given be theſe four, *viz.* 2, 6, 18, 54. And let the Denomination of the *Ratio* be 3. Then (by the *Hypotheſis*) the firſt multiplied by 3 (the equal *Ratio*) is equal to the ſecond (*viz.* 6,) and the ſecond multiplied by (3) is equal to the third (*viz.* 18) and the third multiplied by (3) is equal to the fourth (*viz.* 54.) *Et ſic*, &c.

| | | | | | |
|---|---|---|---|---|---|
| The | Firſt | Term | 2 | is equal to | 2. |
| | Second | | 6 | | 2 into 3. (The firſt Power of the Ratio, or the ſingle Ratio. |
| | Third | | 18 | | 2 into 3, into 3. (The ſecond Power of the Ratio, or the Ratio ſquared. |
| | Fourth | | 54 | | 2 into 3, into 3, into 3 (The third Power of the Ratio, or the Ratio Cubed. |

Or, let the four Numbers be 1, 3, 5, 7, and the common difference 2. Then,

| | | | | | |
|---|---|---|---|---|---|
| The | Firſt | Term | 1 | is equal to | 1 |
| | Second | | 3 | | 1 more by 2. |
| | Third | | 5 | | 1 more by 2, more by 2. |
| | Fourth | | 7 | | 1 more by 2, more by 2, more by 2. |

Here the Greateſt Term (7) is equal to the Leaſt (1,) and as many *differences* as there are more *Terms* beſides the *Leaſt* (*viz.* ſix.) And therefore the *Greateſt* Term 7, leſs by the Leaſt 1, (*viz.* 6) is *Multiplex* of the Difference, according to the number of Terms leſs by One.

III. *If there be three* Numbers *in* Arithmetical Proportion; *the Sum of the two* Extreams *is equal to the double of the* Means.

LET the three *Numbers* be 2, 4, 6, whoſe common difference is 2. Then,

The firſt Term 2, is only 2.

The ſecond Term is 2, more by the difference once (*viz.* 4.)

The third Term is 2, more by the difference twice (*viz* 6.)

And ſo it is evident, that twice (2) the firſt Term, more by twice the difference (4) is equal both to the Sum of the firſt and third Terms; and alſo to the double of the mean term (4,) for 2 and 6 is 8; and ſo alſo is the double of 4.

IV. *If three* Numbers *be in* Proportion, *the Number contained under the* Extreams, *is equal to the* Square *made of the* Mean: *And if the* Number *contained under the* Extreams, *be equal to the* Square *of the* Mean, *thoſe three* Numbers *ſhall be in proportion.*

LET the three Numbers be (2, 6, 18.)

And let the common Ratio be (3.)

The firſt Term is (2.)

The ſecond Term is 2 into 3 (*viz.* 6.)

The third Term is 2 into the Square of 3 (*viz.* 9) equal to 18.

And from hence it is evident, That the firſt Term drawn into the third (*viz.* 2 into 18,) is equal to 2 into 2 (*viz.* 4,) and that into the Square of 3 the common Ratio (*viz.* 9) For 2 into 18 is equal to (36.) And ſo is 4 the ſquare of 2, into 9 the ſquare of 3 equal to 36. Therefore, the Product of the firſt multiplied by the third, is equal to the ſquare of the Mean.

V. *If*

V. *If there be four* Numbers *in* Arithmetical Proportion; *the Sum of the firſt and fourth, is equal to the Sum of the ſecond and third.*

LET the four Numbers be in continual Proportion, as theſe 4, 12, 20, 28, whoſe common difference is (8.)

| | | | |
|---|---|---|---|
| The | Firſt | Term is | 4. |
| | Second | | 4, and once the Difference 8, (*viz.* 12.) |
| | Third | | 4, and twice the difference 16, (*viz.* 20.) |
| | Fourth | | 4, and thrice the Difference 24, (*viz.* 28.) |

Again, Let the four Numbers be four diſcontinued Proportionals; as theſe, 4, 12, 30, 38. And their common difference (8.) Then

| | | | |
|---|---|---|---|
| The | Firſt | Term is | 4. |
| | Second | | 4, and once the Difference 8, (*viz.* 12.) |
| | Third | | 30. |
| | Fourth | | 30, and once the Difference 8, (*viz.* 38.) |

In the four *Continual Proportions* 4, 12, 20, 28 it is evident,

That twice the firſt term 4 (*viz.* 8.) more by thrice the difference 8 (*viz.* 24,) is equal to (32,) which is both the *Sum* of the *Extreams*, (4 and 28,) and of the *Means* (12 and 20.) Alſo,

In the four *diſcontinued Proportionals* 4, 12, 30, 38, it is alſo as evident,

That the firſt term 4, more by the third term 30, more by once the *difference* 8, is equal to 42, which is equal to the *Sum* of the *Extreams* (4 and 38,) and alſo of the *Means* (12 and 32.)

VI. *If there be four* Numbers *in* Proportion, *the Number produced of the* firſt *and* fourth, *ſhall be equal to the* Number *produced of the* ſecond *and* third. *And if the* Number *produced of the* firſt *and* fourth, *be equal to that produced of the* ſecond *and* third; *Theſe* Four Numbers *ſhall be* Proportional.

LET the four *Terms* be four *Continual Proportionals*, as theſe (2, 6, 18, 54.) And let the common *Ratio* be (3.) Then,

| | | | |
|---|---|---|---|
| The | Firſt | Term is | 2. |
| | Second | | 2 into 3, (*viz.* 6.) |
| | Third | | 2 into the ſquare of 3 (*viz.* 9.) |
| | Fourth | | 2 into the Cube of 3 (*viz.* 27.) |

Again, Let the four Numbers be four *Diſcontinued Proportionals*, as theſe, 2, 6, 54, 162, and the equal Ratio (3.)

| | | | |
|---|---|---|---|
| The | Firſt | Term is | 2. |
| | Second | | 2 into the common Ratio 3 (*viz.* 6.) |
| | Third | | 54. |
| | Fourth | | 54 into the common Ratio 3 (*viz.* 162.) |

 In

In the Continual Proportionals it is evident by the Multiplication of Powers:

For the ſquare of the firſt term 2 (*viz.* 4,) multiplied by the Cube of (3) the common *Ratio* (*viz.* 27,) the Product will be 108, which is equal to 2 the firſt term, multiplied by 54 the fourth term, and alſo of 18 by 6, the two mean terms multiplied into each other.

In the four *Diſcontinued Proportionals* 2, 6, 54, 162, it is alſo as evident.

For, 2 (the firſt term) multiplied into 3 (the common *Ratio*) produceth (6,) and that into the third term 54, produceth 324; which is equal, both to the Product of 2 into 162 (the two *Extreams*,) and alſo of 6 into 54, the two *Means*.

VII. *In all* Continual Arithmetical Progreſſions, *the Sum of the* Extreams *is equal to the Sum of any two of the other* Means, *taken equidiſtant from the* Extreams, *and to the* double *of the* middle Term; *when the Number of Places be* Odd.

LET there be theſe ſeven Numbers in *Continual Arithmetical Progreſſion*, *viz.* 3, 6, 9, 12, 15, 18, 21, whoſe common difference is 3.

Firſt, Theſe four *Numbers* 3, 6, 18, 21, are four *Proportionals*: Therefore (by the Vth hereof) *The Sum of their* Means, *and the Sum of their* Extreams *are* equal.

$$\text{For the Sum of}\left\{\begin{array}{l}\text{3 and 21, the two \textit{Extreams}}\\ \text{6 and 18, the two \textit{Means},}\end{array}\right\}\text{are equal to 24.}$$

Secondly, Theſe four Numbers 6, 9, 15, 18, are four *Proportionals*; and therefore, *The Sum of their* Extreams *and* Means *are equal.*

$$\text{For the Sum of}\left\{\begin{array}{l}\text{6 and 18, the two \textit{Extreams},}\\ \text{9 and 15, the two \textit{Means},}\end{array}\right\}\text{is equal to 24.}$$

Thirdly, Theſe three Numbers 9, 12, 15, are three *Proportionals*; and therefore (by the ſame Vth hereof) *The Sum of the* Extreams *is equal to the* double *of the* Mean.

$$\text{For the Sum of}\left\{\begin{array}{l}\text{9 and 15, the two Extreams,}\\ \text{12 and 12, the Mean doubled,}\end{array}\right\}\text{are equal to 24.}$$

$$\text{And ſo}\left\{\begin{array}{lcr}3 & & 21\\ 6 & \text{and} & 18\\ 9 & & 15\\ \text{12 doubled} & & \end{array}\right\}\text{are all equal one to another, \textit{viz.} 24.}$$

VIII. *In* Geometrical Proportionals Continual (*how many soever the* Places *be*) *the* Product *of the* Extreams *is equal to the* Product *of any two of the* Mean Terms, *equidistant from the* Extreams, *and of the* Square *of the* Middle Term; *when the Number of Places be* Odd.

LET the Number of Terms be seven, *viz.* 2, 6, 18, 54, 162, 486, 1458, and their common *Ratio* 3.

First, These four Numbers 2, 6, 486, 1458, are four *Proportionals*; and therefore the *Product* of the two *Extreams* shall be equal to the *Product* of the two *Means*: So

$$\text{The Product of}\left\{\begin{array}{l}2 \text{ into } 1458, \text{ the } \textit{Extreams}, \\ 6 \text{ into } 486, \text{ the } \textit{Means},\end{array}\right\}\text{is equal to } 2916.$$

Secondly, These four Numbers 6, 18, 162, 486, are *Proportionals*: And

$$\text{The Product of}\left\{\begin{array}{l}6 \text{ into } 486, \text{ the } \textit{Extreams}, \\ 18 \text{ into } 162, \text{ the } \textit{Means},\end{array}\right\}\text{is equal to } 2916.$$

Thirdly, These three Numbers 18, 54, 162, are three *Proportionals*; and therefore the *Product* of the two *Extreams*, is equal to the *Square* of the *Mean*. For

$$\text{The Product of}\left\{\begin{array}{l}18 \text{ into } 162, \text{ the two } \textit{Extreams}, \\ 54 \text{ into } 54, \text{ the } \textit{Mean} \text{ into it self},\end{array}\right\}\text{is equal to } 2916.$$

$$\text{And so}\left\{\begin{array}{c}2\\6\\18\\54\end{array}\right\}\begin{array}{c}\\ \text{into}\\ \\ \text{Square}\end{array}\left\{\begin{array}{c}1458\\486\\162\\ \end{array}\right\}\text{are all equal one to the other, and each of them equal to } 2916.$$

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# CHAP. V.

## *Concerning the* Rule of Three, *or* Golden Rule, *both* Single *and* Compound.

THIS Rule may (and most properly) be called the *Rule* of *Proportion*; for that it teacheth (in any case) by having *Three Numbers* given, to find a *Fourth*, which shall be in Proportion to them: And for the Reason of the manner of Working this *Rule*, the *Theorems* delivered in the foregoing *Chapter* will be Subservient.

Now, this Rule is either *Single* or *Compound*.

I. Of

## I. *Of the Single Rule of Three.*

The *Single Rule of Three*, is, When *Three Numbers* are *Given*, and a *Fourth* Proportional *Number required.* And this Rule is either *Direct*, or *Inverse*, or *Reciprocal.*

### I. *Of Direct.*

The *Single Rule of Three Direct*, is, When *Three* Numbers are given, and a *Fourth* is demanded, which bears the same Proportion to the *Third*, as the *Second* bears to the *First.* —As in this following *Example*:

*If* 4 *Acres of Ground cost* 80 *l. What will* 8 *Acres of the like Ground cost?*

For the better understanding of this Operation, look back to the VI[th] *Section* of the foregoing *Chapter*, where you shall find it demonstrated: That, *If there be Four Proportionals, the Product of the First and Fourth, is equal to the Product of the Second and Third.*

Wherefore, In this Example,

If the Product of 8 in 80 (the second and third Terms) produce 640; If that 640 be divided by 4, the first term, the Quotient will be 160; and is the fourth Proportional sought.

And for Proof of this,

Let the fourth term found (*viz* 160,) be multiplied by the first term (4,) the Product will be the same with the Product of the second term (80,) multiplied by the third term (8,) namely (640.)

And from hence we may argue thus,

If the Product of (80 by 8) be equal to the Product of (4 by the unknown number)

Then,

The Quotient will be the very same, whether I divide the Product of (80 by 8,) or whether I divide the Product of (4 by the unknown number) by 4. For either of the Products being 640, the Quotient must needs be 160.

And now it is manifest,

That if I multiply 4 by a 160, and divide that Product back again by 4, it will give 160 for the Quotient: Because, Whatsoever *Multiplication* doth, is undone again by *Division.* And this is the true and genuine *Reason* of the *Operation* of the *Rule of Three.*

And that is to say,

As (4) is found in (80) just 20 times; so (8) is found in (160) just 20 times.

Or thus,

As 4 multiplied by 20 makes (80,) so (8) multiplied by (20) makes (160.)

Another Example.

*If* 80 *l. will buy* 4 *Acres of Land, How many Acres will* 160 *l. buy?*

If you divide the Product of 4 into 160 (*viz.* 640) by (80,) the Quotient will be (8.) For, as (80) contains (4) 20 times, so (160) being divided by (20,) the Quotient will be (8) also.

2. *Inverse,*

2. *Inverse, (or Reciprocal.)*

*The Single Rule of Three Inverse,* is, When there are *Three Numbers* given, and a *Fourth* required, which shall bear the same *Proportion* to the *Second,* as the *Third* doth to the *First.*

As in this Example.

*If a certain quantity of Pecks of Oats will keep* 8 *Horses for* 12 *days; How many days will the same quantity of Pecks keep* 16 *Horses?*

Caution.

*The most Authors that have writ of* Arithmetick, *have made two distinct Rules of this Golden Rule, calling the one* Direct, *and the other* Inverse; *whereas (in truth) they are but One: Only care must be taken how to place the Terms given.*

So in this *Example,* Look what Proportion 16 Horses bear to 8 Horses; the like Proportion do 12 days bear to a fourth number of days: And the Terms ought to be thus placed.

As 16 Horses, to 8 Horses; so 12 days to 6 days. And then the Operation is the very same as before: For the Product of 8 by 12 is (96,) which being divided by 16, the Quotient is (6) days.

## II. *Of the Double, or Compound Rule of Three.*

THE *Double,* or *Compound Rule of Three,* is, When more Numbers than *Three* are given: And it is either *Direct* or *Inverse.*

I. *Direct.*

Example 1. *If* 4 *Men spend* 19 *Pound in* 3 *Months; How many Pounds will* 8 *Men spend in* 9 *Months?*

The Solution is thus performed.

(1.) If 4 Men spend 19 Pound, what will 8 Men spend?

Set the Numbers thus.

| Men | Pounds | Men | Pounds |
|---|---|---|---|
| 4 | 19 | 8 | 38 |

For 19 in 8 (the two *Mean Terms*) produce 152, which divided by 4 (the given *Extream*) the *Quotient* is 38 (the other *Extream.*)

(2.) *If* 38 *Pound be spent by any number of Men in* 3 *Months; How many Pounds will be spent by the same number of Men in* 9 *Months;*

Set the Numbers thus:

| Months | Pounds | Months | Pounds |
|---|---|---|---|
| 3 | 38 | 9 | 114 |

For,

For, 38 in 9 (the two *Mean Terms*) produce 342; which divided by 3 (the given *Extream*) the *Quotient* will be 114 (for the other *Extream.*) And ſo many *Pounds* will 8 *Men* ſpend in 9 *Months.*

II. *Inverſe.*

Example 2. *If* 9 *Buſhels of Oats will ſerve* 8 *Horſes for* 12 *days; How many days will* 24 *Buſhels ſerve* 16 *Horſes?*

The Solution is thus performed.

1. As 9 Buſhels is to 12 days, ſo is 24 Buſhels to 32 days.

Set the Number thus.

| Buſhels | Days | Buſhels | Days |
|---|---|---|---|
| 9 | 12 | 24 | 32 |

For, 12 in 24 (the two *Means,*) produce 288, which divided by 9 (the given *Extream,*) the *Quotient* is 32 (for the other *Extream.*)

2. As 16 *Horſes* is to 8 *Horſes*; ſo is 32 *Days* to 16 *Days.*

Set the Numbers thus.

| Horſes | Horſes | Days | Days. |
|---|---|---|---|
| 16 | 8 | 32 | 16 |

For 8 in 32 (the two *Means*) produce 256, which divided by 16 (the given *Extream,*) the *Quotient* will be 16 for the other *Extream.*

And let this ſuffice for the *Reaſon* of the *Operation* of the *Golden Rule.*

## CHAP. VI.

### *Of the Increaſe of* Swine, Corn, Sheep, *&c.*

#### I. *Of Swine.*

*Unto what Sum of Money may all the Pigs that One Sow, with all the Pigs of her Race, and the Increaſe iſſuing of them, in Twelve Years time, amount unto?*

SUppoſe the Sow brings forth but ſix Pigs at a Litter, of which we will allow two to be Barrow (which is as little as can be ſuppoſed.) And then imagine that every of thoſe four, bring as many every Year; and the increaſe of them the like, during the Term of twelve Years.

This

This is performed by *Geometrical Progression*, where the common *Ratio* is 4, and the Sum of all the Numbers is 22369620, i. e. *Twenty two Millions, 369 thousand, Six hundred and twenty Pigs.*

| The Increase. | Year. |
|---|---|
| 4 | I |
| 16 | II |
| 64 | III |
| 256 | IV |
| 1024 | V |
| 4096 | VI |
| 16384 | VII |
| 65536 | VIII |
| 262144 | IX |
| 1048576 | X |
| 4194304 | XI |
| 16777216 | XII |
| 22369620 | |

Now for the maintenance of these *Pigs*: Suppose *Five shillings* be allowed for to maintain one of these *Pigs* for a *Year*, (which is little enough, for it is not half a Farthing a day,) yet there must be 22369620 *Crowns* to maintain them all for one Year, which number being divided by 4, the Quotient will be 5592405, which is *Five Millions, Five hundred ninety two Thousand, Four hundred and five Pounds* Sterling for one Year.

## II. *Of Corn.*

*What quantity of* Ground *will be capable of receiving one Grain of Corn and the increase of it for eight Years*; and to what number of Grains will the increase of that one Grain arise unto.

FOR the first Year, let there be allowed *one quarter of an Inch of Ground* to sew the *one Grain* in (which is, indeed, too little) and this *Corn* we will suppose had in the ear, at the Years end, 40 *Corns* (for that is but reasonable) then the second Year we must allow 40 square quarters of Inches of *Ground* to sew those 40 *Corns* in, that is, 10 square inches of Ground. And the third Year, supposing those 40 Corns to produce 40 *Ears*, and in each *Ear* 40 *Corns*, as before, they will be in the third Year increased to 1600 *Corns*; so that there must be 1600 *square quarters of Inches of Ground* to sow that Increase in, which is 40 *square Inches*, and thus continuing till the eight Years be expired, the *Increase* would be at the eight Years end 163840000000 Corns, as in the *Table*, in the Margin (where the common *Ratio* is 40). And the Sum of all the *Corns* in the *Table* do amount unto 168041025641 *Corns*, and consequently so many *square quarters of Inches of Land* must be allowed for the *sowing* of those *Corns* in; one fourth part whereof is 42010256410 *square Inches* of Land to sow this increase in, that is, *Forty two Millions of Millions, ten Millions, Two hun-*

| Increase in Corns, and Ground. | | Year. |
|---|---|---|
| | 1 | I |
| | 40 | II |
| | 1600 | III |
| | 64000 | IV |
| | 2560000 | V |
| | 102400000 | VI |
| | 4096000000 | VII |
| | 163840000000 | VIII |
| Corns | 168041025641 | |
| Inches of Land | 42010256410 | |

 *dred*

*dred sixty four Thousand, Four hundred and ten Inches.* Now note, That in one Acre of Land, there is contained 6272640 square Inches; wherefore divide the 42010256410 Inches, by 6272640 (the *Inches* in one *Acre*) and the *Quotient* will be 6697 *Acres*; and so much Land would be required to contain the sowing of the increase of one *Corn* in *eight Years*; which if Land were rated but at *Five Shillings* the *Acre* for a *Year*, it would amount to 1674 Pounds Five Shillings a year *Rent* for the Ground to Sow this one Corns Increase in, in eight years time.

Upon such a Condition, a *Country Fellow* agrees with a *Rich Farmer* to serve him for eight Years, he requiring no other *Wages*, than *One Corn*, and *One quarter of an Inch of Land* to Sow it in, for the first Year, and so on for the whole eight Years: Now I do question at the eight Years end which was the *Richest Man*, the *Farmer* or his *Servant*.

## III. *Of Barley.*

*Unto what Quantity of* Barley *will one Corn arise unto, that one Corn being doubled (according to* Geometrical Progression) 72 *times: Also the* Worth *of so much* Barley *in Money: The* Weight *of so much: How it should be removed: And where stowed.*

### I. *For the Quantity of it.*

IF we allow *Ten thousand* Corns to a *Pint* (which is more than enough) then 5120000, that is, *Five millions, one hundred and twenty thousand* Corns will make a *Quarter*; notwithstanding (for the ease of such as will make trial) we will allow 10000000, *Ten millions of Corns* to make a *Quarter*; by which number, if you divide the whole number of Corns, that will arise in the 72 place, being doubled (because we make a Quarter to contain 10000000 *Corns*; whereas it does contain little more than half so many (*viz.* 5120000 *Corns*) and that may be done by cutting off the seven last figures towards the right hand: Then the Quotient of that division will be found to be 472236648286964: And so many whole *Quarters* of *Barley* would the number of Corns in the 72 place have amounted to, besides some odd *Bushels* which we omit.

### II. *For the* Worth *of so much Barley.*

Suppose it were rated at 15 Pence the Bushel (which is a very low rate) that is 10 Shillings the *Quarter*, and then it would amount unto 236118324143483 Pounds Sterling; which Sum rendred in words is, *Two hundred thirty six millions of millions; One hundred and eighteen, three hundred twenty four millions; One hundred forty three thousand; Four hundred eighty three.*——And thus, If you reckon *Land* for ever worth twenty Years Purchase: If you divide this Sum of Pounds by 20, the Quotient is 11805916207174, that is, *Eleven millions of millions, eight hundred and five thousand, nine hundred and sixteen millions, two hundred and seven thousand, one hundred seventy four Pounds* a year. And again, If you divide this number of Pounds by 365 (the *days* in one *year*) the Quotient

Quotient will be 32344975910, that is, *Thirty two thousand three hundred forty four Millions, nine hundred seventy four Thousand, nine hundred and ten Pounds a day* for ever.

### III. *For the* Weight *of this Barley.*

If we allow eight *Bushels* (or one *Quarter*) to weigh two hundred Weight (but doubtless it weighs more) then the whole number of *Quarters*, viz. 472236648286964, multiplied by 2, gives the *Weight* of all the *Barley* to be 944473296573928 *hundred Weight*. And if you divide this number by 20 (the number of *Hundreds* in one *Tun*) the Quotient will be 47223664828696 Tuns, that is, *Forty seven Millions of Millions, two hundred twenty three thousand six hundred sixty four Millions, eight hundred twenty eight Thousand, six hundred ninety six Tuns.*

### IV. *For the Stowage of this Barley.*

If we suppose one Ship to contain a *Thousand Tun*; then must there be 47223664828, that is, *Forty seven thousand two hundred twenty three Millions, six hundred sixty four thousand, eight hundred twenty eight*, such Ships to carry it: And, if there were *four Millions* of *Nations* in the *World*, and every one of those *Nations* had *Ten thousand Sail* of Ships of a *Thousand Tun* a-piece, yet all those *Ships* would not contain it. By what is here delivered, you may see how prodigiously *Numbers* do increase by being multiplied according to *Geometrical Progression.*

## IV. *Of other Grain.*

MUstard-seed is a *Grain* of very great Production; for would one imagine that *one Grain* of *Mustard-seed*, and its Increase for 20 Years, cannot be contained within the *Visible World*; nay, if it were 100 times greater than it is, it holding nothing besides, from the Center of the *Earth* to the *Firmament*: For proof of which by Art, Let us suppose, that one Grain of Mustard-seed sown, to bring forth a *Tree* or *Branch*, in each extendure of which might be a Thousand Grains; but we will suppose only One thousand in the whole Tree: And then proceeding to a *Progression* of 20 Years, where the common *Ratio* must be 1000, in less than 17 Years you shall have so many *Grains* which will surpass the *Sands* which are able to fill the whole *Firmament*: For, according to the Supposition of *Archimedes*, and of *Tycho-Brahe*, of the Greatness of the *Firmament*, the number of Grains of Sand to fill that capacity, will be sufficiently expressed by an Unite and 49 Cyphers: But the number of *Grains* of *Mustard-seed*, at the end of 17 years, will be an Unite and 52 Cyphers; and besides, Grains of *Mustard-seed* (though very small) are far greater than grains of *Sand*: It is therefore evident, That at the 17th years end, that which shall successively spring from one *Grain* only, cannot be contained within the limits of the whole *Firmament*; what then would it be, if multiplied again by 1000 for the 18th Year, and that again by 1000 for every years increase till you come to the 20th year? It is very evident, that such a heap of Mustard-seed would be One hundred thousand times greater than the Earth.

 V. *Of*

## V. *Of Sheep.*

*Unto what Sum of Money will* 100 *Sheep and the Increaſe of them, being preſerved for the ſpace of* 16 *Years, amount unto?*

SUppoſe a Man at the beginning of the Year were poſſeſſed of 100 *Sheep*, and that every one of them ſhould produce but one *Lamb* every year, unto what will theſe 100 with their increaſe amount to at 16 years end?

| Years. | Increaſe. |
|---|---|
| I | 200 |
| II | 400 |
| III | 800 |
| IV | 1600 |
| V | 3200 |
| VI | 6400 |
| VII | 12800 |
| VIII | 25600 |
| IX | 51200 |
| X | 102400 |
| XI | 204800 |
| XII | 409600 |
| XIII | 819200 |
| XIV | 1638400 |
| XV | 3276800 |
| XVI | 6553600 |

This is eaſily reſolved by a *Geometrical Progreſſion*, as in the Margin; wherein you may ſee, that at the expiration of the 16th year the *Sheep* will be increaſed to 6553600, which is, *Six Millions, five hundred fifty three Thouſand, ſix hundred Sheep:* Which if reckoned but at *five Shillings* a-piece, it will amount unto 1638400, that is, *One Million, ſix hundred thirty eight Thouſand, ſix hundred* Pound.

## VI. *Of Men.*

IT may ſeem hard to conceive, that from eight Perſons which were ſaved after the *Deluge*, or *Noah's Flood*, ſhould ſpring ſuch a World of People to begin a *Monarchy* under *Nimrod*, being but 200 years after the *Flood*; and that amongſt them ſhould be raiſed an *Army* conſiſting of *Two hundred thouſand* Fighting Men: But it is eaſily proved: For, if we take but one of the Children of *Noah*, and ſuppoſe that a New Generation of People begin at every 30 years, and that it be continued to the ſeventh Generation, which is 210 years; for then, of one only Family there would be produced 111305, that is, *One hundred and eleven thouſand, three hundred and five* Souls to begin the World; although in that time Men lived longer, and were more capable of Generation, Multiplication and Increaſe. Now ſuch a Number ariſing only from a ſimple Production of only *One* yearly, would be far Greater, if one Man ſhould have many Wives (as in ancient times they had.) And from hence it is alſo, that the Children of *Iſrael*, who came into *Egypt* only *Seventy* Souls, yet after 210 years Captivity, they came forth with their *Hoſts*, ſo that there was told *Six hundred thouſand Fighting Men*, beſides *Old People, Women* and *Children*: And he that ſhall ſeparate but one of the Families of *Joſeph*, it would be ſufficient to make up that Number: And how much more would it be then, if many *Families* were joyned together?

CHAP.

# CHAP. VII.

## *Of Changes in Bells; in Musical Instruments, &c.*

### I. *Of Changes in Bells.*

IT is often disputed among common *Ringers*, what Number of *Changes* may be made in 5, 6, 7, 8, or any other Number of *Bells*. This and such like *Questions* may be easily resolved; for it is but multiplying every number from the *Unite* successively into each others *Product*, unto the number of *Unites* assigned; according to which the following *Table* is made, as is easy to perceive: And so the Number standing against VI in the *Table*, is 720, and so many *Changes* may be made upon *Six* Bells; 5040 upon Seven, *&c.*

### II. *Of Voices.*

If it were required to know how many *Consorts* Ten *Voices* will make, each man keeping his own *Note*, but altering his Place; against the Number X in the *Table* you find this number 3628800; which is *Three millions, six hundred twenty eight thousand, and eight hundred*; and so many Consorts may be made of Ten *Voices*.

It it also the same in *Stringed Instruments*; and the *Gamauth* may be varied.

A Table of CHANGES, *&c.*

| | | |
|---|---|---|
| I | a | 1 |
| II | b | 2 |
| III | c | 6 |
| IV | d | 24 |
| V | e | 120 |
| VI | f | 720 |
| VII | g | 504,0 |
| VIII | h | 403,20 |
| IX | i | 362,880 |
| X | k | 362,880,0 |
| XI | l | 399,168,00 |
| XII | m | 479,001,600 |
| XIII | n | 622,702,080,0 |
| XIV | o | 871,782,912,00 |
| XV | p | 130,767,436,800,0 |
| XVI | q | 209,227,898,880,00 |
| XVII | r | 355,687,428,096,000 |
| XVIII | s | 640,237,370,572,800,0 |
| XIX | t | 121,645,100,408,832,000 |
| XX | v | 243,290,100,817,664,000,0 |
| XXI | w | 510,909,421,717,094,400,00 |
| XXII | x | 112,400,072,777,760,768,000,0 |
| XXIII | y | 258,521,167,388,849,766,400,00 |
| XXIV | z | 620,448,401,733,239,439,360,000 |

accord-

according to this, anſwerable to the *Number* ſtanding againſt XXII, namely, 1124000727777607680000 *Notes.*

### III. *Of Changes of Places.*

Into how many ſeveral *Poſitions* may the Twelve Figures about the *Dial-Plate* of a *Watch* or *Clock-Dial* be placed? The work is eaſily done, for the Number ſtanding againſt XII in the *Table* will reſolve you, *viz.* 479001600, which is, *Four hundred ſeventy nine millions, one thouſand and ſix hundred times.* And according to this way there was a pretty Bargain made between a *Young Scholar* and a *Countrey Gentleman*; which is this:

*A Young Scholar being come to a Countrey Town where he intended to reſide ſome time, lit into a Gentleman's Houſe, where there were in Family the Maſter, Miſtreſs, and Four Children, which with himſelf made Seven. At dinner they diſcourſed concerning the Scholar's Board there for a Year, for which the Gentleman demanded a certain Sum of Money; which the Scholar thinking too much, made this Overture; That he would give him ſo much for a Year as he did demand, provided, That for that ſame Money he ſhould have his Board ſo long time as he could daily place thoſe Seven Perſons that were then at the Table, in a ſeveral and diſtinct Order, ſo that they ſhould never all of them ſit in the ſame Places as then they did: The Gentleman condeſcends: The Queſtion is, How many days may the Scholar ſojourn with the Gentleman, before all theſe Changes of Places come about?*

Look in the Table for the *Number* ſtanding againſt VII, and you ſhall find it to be 5040, ſo that the *Scholar* (according to this Agreement) muſt ſojourn with him *Five thouſand and forty* days, which is Fourteen years wanting 70 days; and that at Three-Pence a day will amount unto *Threeſcore and three Pounds* Sterling.

### IV. *Of the Letters of the Alphabet.*

From hence it is no marvel, that from the mutability of Tranſmutations, out of the 24 *Letters* of the *Alphabet*, there ariſeth and is made ſuch Variety of *Languages* as are in the world, and ſuch infinite number of *Words* in each *Language*, ſeeing the diverſity of *Syllables* produceth that effect; and alſo by the interchanging and placing of *Conſonants* among the *Vowels*, and amongſt themſelves; ſince this Alphabet of XXIV Letters may be varied ſo many times as the Number againſt XXIV amounteth to; *viz.*

620448401733239439360000.

Which is,

*Six hundred and twenty thouſand, four hundred forty eight myriads, four hundred and one thouſand ſeven hundred thirty three thouſand two hundred thirty nine millions of millions, four hundred thirty nine thouſand millions, three hundred and ſixty thouſand.*

Now if from hence we ſhould allow that a man may read or ſpeak *One hundred thouſand Words* in an *hour*, which are as many as are contained in all the *Goſpels* of the *Four Evangeliſts*, and in the *Acts* of the

*Apoſtles*

*Apoſtles* alſo, (a Task too great for a man to do in ſo ſhort a time) and if there were *Four thouſand ſix hundred and fifty thouſand millions of men*, they could not ſpeak all the *Words* that the 24 Letters are capable to make (according to the hourly proportion aforeſaid) in 70000 *Three-ſcore and ten thouſand years*; which number of *Words* if they ſhould be written in *Books*, each *Book* being 15 inches long, 12 broad, and 6 thick, the *Books* made of the aforeſaid Tranſmutation of the 24 Letters, would be 38778037089928788. And if a *Library* of a *Mile Square* every way, of 50 foot high, and in which were 250 *Galleries* of 20 Foot broad apiece, it would contain but *Four hundred millions* of the ſaid *Books*: So that there muſt be to contain the reſt no leſs than 96945092, *Ninety ſix millions, nine hundred forty five thouſand, ninety two*, ſuch *Libraries*: And if the *Books* were extended over the ſuperficial ſurface of the whole *Earth*, it would be a Decupal Covering to the ſame.——And it is from hence that *Tacquet* in the 8*th. Chapter* of his 5*th. Book* of *Arithmetick* affirms, That the *Permutation* of 24 *Letters* are ſo numerous, that a *Thouſand millions* of able *Clerks*, in a *Thouſand millions* of *years* (not ſparing *Dominicals* nor *Feſtivals*) were not able to tranſcribe them. And *Galdinus* aſſerts, That the *Books* which might be compiled of the variety of 23 *Letters* only (accounting 1000 *Pages* to each *Volume*, and 100 *Lines* to each *Page*, and 60 *Letters* to each *Line*, and not any two *Words* in any of thoſe *Volumes* the ſame) would do more than twice cover the whole Superficies of the *Earth* and *Sea*: Nay farther, he ſeems to be of opinion, that the Paper of thoſe *Volumes* laid ſingly *Sheet* by *Sheet*, would cover the very *Firmament*.

And as in the Tranſpoſition of *Letters*, ſo alſo in the Tranſpoſition of the *Nine Digit Figures*, which with the *Nul.* or *Cypher* makes *Ten*, are capable of 3628800, that is, of *Three millions, ſix hundred twenty eight thouſand, and eight hundred* Changes. And in Mr. *Henry Briggs* his *Logarithms* to 100000, conſiſting of *Sixty nine* Sheets, in each *Sheet* Four *Pages*, and in each *Page Four hundred and fifty numbers*, in all 124200; i. e. *One hundred twenty four thouſand and two hundred Numbers*. And in the *Canon* of *Sines Tangents* and *Secants* of the ſame Book, conſiſting of 22 *Sheets* and a half, in which are *Forty Pages*, and in each *Page Three hundred and ſixty numbers*; in all 16200; *i. e. Sixteen thouſand and two hundred* Numbers, which with thoſe of the *Logarithms*, make together 140400, i. e. *One hundred and forty thouſand and four hundred numbers*, and not two *Numbers* exactly the ſame in both the *Books*: Yet notwithſtanding this vaſt *Number*, it is leſs than the *Number* againſt X in the *Table* by 3488400: Nay, it is very little above the *Twenty ſixth* part thereof: So that if *Twenty ſix* ſuch *Books*, all of *Numbers*, and each *Book* to contain *One hundred and forty thouſand four hundred numbers*, and not any two *numbers* the ſame in all the *Books*, they would but contain the number of the Number that the Table exhibits againſt X in the Table.

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CHAP.

# CHAP. VIII.

## *Of* Arithmetical Verſifying.

*Shewing an Artificial way, How from any* Six *or* Five *of the* Nine Digit Numbers (*promiſcuouſly taken, or ſet down at all adventures*), *to make both* Hexameter *and* Pentameter Latin Verſes, *which ſhall be* Good Latin, *and* Good Senſe; *altho the Party which writes the* Verſe *from the* Six *or* Five Figures *ſo ſet down, doth not underſtand any thing of the* Latin Tongue.

The Fundamental SCHEME.

| | 1ſt. *Fig.* | 2d. *Fig.* | 3d. *Fig.* | 4th. *Fig.* | 5th *Fig.* | 6th. *Fig.* |
|---|---|---|---|---|---|---|
| 1 | Perfida | Verba | Vides | Promittunt | Fœdera | Certa |
| 2 | Horrida | Jura | Viro | Monſtrabunt | Somnia | Multa |
| 3 | Turbida | Fata | Tibi | Prædicunt | Pocula | Semper |
| 4 | Sordida | Dicta | Scio | Producunt | Dogmata | Sola |
| 5 | Candida | Dona | Reor | Caſaubunt | Crimina | Tantum |
| 6 | Turpia | Vota | Malis | Portabunt | Pignora | Quædam |
| 7 | Aſpera | Facta | Mihi | Confirmant | Jurgia | Prava |
| 8 | Triſtia | Bella | Inquſam | Procurant | Sidera | Sæpe |
| 9 | Impia | Damna | Aliis | Concedunt | Tempora | Plana |
| | 3 | 4 | 5 | 2 | 1 | |

*How to make* Hexameter *Verſes by the Scheme.*

Let Six Figures be written by any perſon, as theſe 8, 6, 4, 3, 9, 5, or any other.

| | | | | | |
|---|---|---|---|---|---|
| | *8 the Firſt* | | *Firſt Figure* | | Triſtia |
| | *6 the Second* | *Figure in the Firſt* | *Second Figure* | | Vota |
| *Find* | *4 the Third* | *Column of the Scheme* | *Third Figure* | *You ſhall find* | Scio |
| | *3 the Fourth* | *towards the Left Hand,* | *Fourth Figure* | *this Word* | Prædicunt |
| | *9 the Fifth* | *and under the Title* | *Fifth Figure* | | Tempora |
| | *5 the Sixth* | | *Sixth Figure* | | Tantum |

Which Words make this *Latin Hexameter* Verſe,

8 6 4 3 9 5
Triſtia Vota Scio, Prædicunt Tempora Tantum.

And from any Five Figures collected by the bottom of the Scheme (as theſe 1, 9, 7, 2, 6,) may be made this or any other *Pentameter* Verſe. *Example,* 1, 9, 7, 2, 6.

1 9 7 2 6
Fœdera Concedunt Aſpera Jura Malis.

CHAP.

# CHAP. IX.

## *Of Numerical Enigmatical Problems.*

### PROBL. I.

*If 136 Pound be to be divided between two perſons, ſo that one muſt have 18 Pound more than the other; How much muſt each perſon have?*

FRom the given Sum (136) ſubſtract (18) the overplus that one perſon muſt have above the other, and the Remainder will be (118) the half whereof is (59); and ſo much muſt the one perſon have: And if you add (18) to (59) the Sum will be (77); and ſo much muſt the other perſon have; for theſe two numbers (77 and 59) added together, do meke up the whole Sum of (136 Pound).

### PROBL. II.

*If 136 Pound be to be divided between two perſons, in ſuch ſort, that the Leſſer Share ſhall have ſuch Proportion to the Greater Share, as 2 hath to 5; What muſt each perſon have?*

FOR the Working of this or the like Queſtion, this is the RULE, or Analogy.

As the Sum of the two Proportional terms 2 and 5, (*viz.* 7.)
Is to the Sum given to be divided (*viz.* 136.)
So is (2) the Leſſer of the Proportional Terms given,
To ($38\frac{6}{7}$) the Leſſer Share: And ſo is (5) the Greater Proportional Number given, To ($97\frac{1}{7}$) the Greater Share.

So if you multiply the given Number (136) by (2) the Leſſer Proportional, the Product will be (272) which being divided by the Sum of the Proportionals (7), the Quotient will be ($38\frac{6}{7}$), which is the Leſſer Share. —— Or if yon multiply the given number (136) by (5) the Greater Proportional, the Product will be (680), which divided by (7), the Quotient will be ($97\frac{1}{7}$), for the Greater Share; and theſe two ($38\frac{6}{7}$ and $97\frac{1}{7}$) added together, do make (136), equal to the Number given to be divided.

### PROBL. III.

*There is a certain number of Pounds to be diſtributed among Six perſons, in ſuch ſort that each perſon from the firſt ſhall have 7 Pounds more than the other, and at the end the laſt perſon had juſt as many Pounds more as the firſt: What was the Sum of Money, and how much had each perſon?*

LET the Six perſons be repreſented by theſe Six Letters, A B C D E F; then ſuppoſe that the firſt perſon A had 3 Pounds, then B

must have 10, C 17, D 24, E 31, and F 38, as in the Margent: But (by the tenure of the Problem) the share of F should be but just double to that of A, but it is much more; wherefore substract A's share 3, from F's share, 38, and the remainder will be 35; which is the number of Pounds that A must have; and then B must have 7 more (*viz.* 42.) and C 49, D 56, E 63, and F 70, which is just double to what A had; which answers the Question as to that part: Then, these shares added together, do make 315 Pound, and that was the number of Pounds to be divided.

| | | |
|---|---|---|
| A | 3 | 35 |
| B | 10 | 42 |
| C | 17 | 49 |
| D | 24 | 56 |
| E | 31 | 63 |
| F | 38 | 70 |
| | 35 | 315 |

## PROBL. IV.

*There were Five Bags of Money, and in the biggest Bag there was as many more Pounds as there was in the least, and in the middle Bag there was half as much as there was in the biggest and least together; and each Bag from the least had in it 30 Pound more than the other: What number of Pounds was in each Bag?*

LET the Five Bags be represented by these Five Letters, G H K L and M, and suppose there was in the least Bag G 4 Pound, then must there be in the Bag H 34, and in K 64, and in L 94, and in M 124. But the Bag M holds much more than double that of G, wherefore substract G 4, from M 124, and there will remain 120, and so much Money must be in the least Bag G, as in the Margent: Then (because every Bag exceeds other by 30 Pound), there must be in H 150 Pound, in K 180 Pound, in L 210 Pound, and in M 240: And then M is double to G, for 120 doubled is 240, equal to M, and G and M together is equal to 360, the half whereof is 180, and so much is there in the middle Bag K; and the Money in all the Bags is equal to 900 Pounds: And so is the Question answered in all particulars.

| | | |
|---|---|---|
| G | 4 | 120 |
| H | 34 | 150 |
| K | 64 | 180 |
| L | 94 | 210 |
| M | 124 | 240 |
| | 120 | 900 |

## PROBL. V.

*If 136 Pound be to be divided into two parts between* A *and* B, *so that* B *shall have 25 Pound more than* A, *what is each share?*

FRom 136 (the Sum) substract 25 (the excess that B must have more than A), and the remainder will be 111, the half whereof is 55 *l.* 10 *s.* for A; and that added to 25 the excess, it makes 80 *l.* 10 *s.* for B; for 55 *l.* 10 *s.* and 80 *l.* 10 *s.* is equal to the Sum 136 *l.*

PROBL.

## PROBL. VI.

*If 560 Pound be to be divided between* A *and* B, *in such proportion as 2 Pound hath to 7 Pound, what must each have?*

THE Sum of the two Proportional Terms 2 and 5 make 7; wherefore by the Golden Rule,

As 7 is to 560, so is 2 the lesser Proportional to 160 the lesser Share; and so is 5 the greater Proportional to 400 the greater Share; which together make 560 Pound, the Sum to be divided.

## PROBL. VII.

*There was a May-Pole which consisted of three pieces of Timber, of which the first (or lowermost) was 13 foot long, the third (or uppermost piece) was as long as the lowermost piece, and half the middle piece; and the middle piece was as long as the uppermost and lowermost together: How high was this May-Pole, and how long each Piece?*

MUltiply the length of the first piece 13, by 3 and by 4, so shall the two Products be 39 and 52, for 13 by 3, is 39 for the length of the uppermost piece; and 13 by 4, is 52 for the length of the middle piece, which 52 is equal to 13 the lower piece, and 39 the upper piece added together; and the height of the May-Pole was therefore 104 Foot.

## PROBL. VIII.

*A* Grandfather *living in the house with his* Son, *and his* Son's Wife, *and their* Three Sons, *and discoursing concerning their* Ages, *the* Father *said, I am as old as my* Wife *and* Second Son, *and four years over.* ——*The* Wife *said that she was as old as all her three* Sons, *and three years over.* ——*The* Eldest Son *said that he was as old as his two younger* Brothers, *and 3 years over.* —— *And the* Second Son *said he was four times the age of his younger brother, and one year over. And when all their Ages were added together, they proved to be the just Age of the* Grandfather, *who was then 125 years old. What was the age of the* Father, Mother, *and all the three* Sons?

FOR the resolving of this and the like *Questions*, suppose the youngest Son to be *One* year old, then the second must be 4 years, and 1 over, and the eldest as old as both the other, that is, 5 years, and 3 over. Also the *Mother* must be as old as all the three *Sons*, which is 10 years, and 3 over: And consequently by the Tenor of the *Question*, the *Father* being the Age of his *Wife* and *Second Son*, must be 14 years old, and 4 over.

Which set down in this manner,

| | |
|---|---|
| The Youngest Son was old | 1 Year. |
| The Second Son was then | 4 Years, and 1 over. |
| The Eldest Son was then | 5 Years, and 3 over. |
| The Mother then must be | 10 Years, and 3 over. |
| The Father must then be | 14 Years, and 4 over. |
| All which added together make | 34 Years, and 11 over. |



But

But according to the tenor of the *Queſtion*, all their Ages together ſhould be equal to the Age of the *Grandfather*, which was 125 years: Wherefore, to find the Age of the *youngeſt Son*, you muſt work by the Rule of Proportion thus: Saying,

As 34 years
Is to 1 year (the ſuppoſed Age of the *youngeſt Son*)
So is 125 years (the Age of the *Grandfather*.)
To $3\frac{12}{34}$, or in Decimals thus, 3. 352 years,
For the Age of the youngeſt Son.

And then

| | | | | |
|---|---|---|---|---|
| The Youngeſt Son | 3. 352 | | | 3. 352 |
| The Second Son | 13. 408 and | 1 over, | that is, | 14. 408 |
| The Eldeſt Son | 16. 760 and | 3 over, | | 19. 760 |
| The Mother | 33. 520 and | 3 over, | | 36. 520 |
| The Father | 46. 928 and | 4 over, | | 50. 928 |
| | 113. 968 and | 11 over | (that is) | 124. 968 |

The Sum here is 113. 968 years, to which the 11 years over being added in their due places, as in the ſecond part of the Example they are, the Sum will be 124. 968 years, equal to the *Age* of the *Grandfather*; and the *Queſtion* reſolved in every particular.

## PROBL. IX.

*If* 222 Crowns *be to be divided among three* Perſons *A B and C, in ſuch proportion that C ſhall have 9 times as many as B, and 6 times as many as A wanting Ten.——And B ſhall have 7 times as many as A, and 25 over: How many Crowns muſt A have, and alſo B and C?*

SUppoſe A to have only one *Crown*, then by the *Queſtion*, B muſt have 7 Crowns, and 25 over; and C muſt have 9 times as many as B, that is 63, and 6 times as many as A, that is 6, in all 69 wanting 10; which ſet in this manner.

A 1 Crown.
B 7 Crowns, and more 25.
C 69 Crowns wanting 10.

The Sum 77 Crowns, more 25, wanting 10.

Subſtract the 10 wanting from the 25 more, and then there will remain 15 over; Subſtract 15 from 222, and there will remain 207, for a dividend, and the Sum 77 muſt be the diviſor; wherefore divide 207 by 77, and the Quotient will be $2\frac{53}{77}$ (or in Decimals 2 688) for the ſhare of A, and then A having 2. 688, B muſt have 7 times as many, that is 18. 816, and 25 over; and C muſt have nine times as many as B, which is 169. 344, and ſix times as many as A, which is 16. 128, which together

| | |
|---|---|
| A having | 2. 688. |
| B muſt have | 18. 816 and more 25. |
| C muſt have | 185. 472 wanting 10. |
| The Sum | 206. 976. |

together makes 185. 472, wanting 10; all which being added together as above, do make 206. 976, to which the 25 over being added, and the 10 wanting subftracted in their due places, the Sum will be 221. 976, that is, 222 Crowns, and anfwers the Queftion.

| | | | |
|---|---|---|---|
| A | 2. 688, | that is, | 2. 688. |
| B | 18. 816 more 25, | | 43. 816. |
| C | 185. 472 wanting 10, | | 175. 472. |
| | 206. 976 more 25 want 10. | | 221. 976. |

## PROBL. X.

*There are four* Weights *A B C D, all which together do weigh* $324\frac{1}{2}$ *Pound, of which B weighs more than A by 9 Pound, C weighs three times as much as A, and four times as much as B; and D weighs 6 times A, 3 times B, and once and a half C; their refpective weights are demanded.*

LET the weight A be fuppofed to weigh only one Pound, then B muft weigh 1 Pound and 9 over; and C muft weigh 3 times A which is 3, and 4 times as much as B which is 4, which together make 7 for C; and then D muft weigh 6 times A, 3 times B, once and a half C, and 4 times B, which together make $19\frac{1}{2}$; all which added together do make $28\frac{1}{2}$ more by 9, which fhould be equal to $324\frac{1}{2}$; Subftract the 9 which is over, from $324\frac{1}{2}$, and the remainder will be $315\frac{1}{2}$ for a Dividend, and the Sum $28\frac{1}{2}$ is the Divifor: Divide $315\frac{1}{2}$ by $28\frac{1}{2}$ (or decimally 315. 5. by 28. (5) the Quotient will be 11. 07 for the weight of A. Then

| | |
|---|---|
| A | 1. |
| B | 1 more 9. |
| C | 7. |
| D | $19\frac{1}{2}$. |
| Sum | $28\frac{1}{2}$ more 9. |

| | | | |
|---|---|---|---|
| A weighing | 11. 07, | or | 11. 07 |
| B muft weigh | 11. 07 + 9, | | 20. 07 |
| C muft weigh | 77. 49, | | 77. 49 |
| D muft weigh | 215. 86, | | 215. 86 |
| Their Sum | 315. 49 + 9, | or | 324. 49 |

which anfwers the Queftion.

## PROBL. XI.

*Three* Merchants *build a* Ship *which coft* 6000 *Pound, of which A paid* $\frac{1}{4}$ *part, B* $\frac{1}{5}$ *part, and C* $\frac{1}{6}$ *part; What did each pay?*

MUltiply the Denominators of the feveral Fractions $\frac{1}{4}\frac{1}{5}\frac{1}{6}$, and they make 120; divide this 120 by each feveral Denominator, as by 4, by 5 and by 6, and the Quotients will be 30, 24 and 20,

$$\text{For 120 divided by}\left\{\begin{matrix}4\\5\\6\end{matrix}\right\}\text{giveth for its Quotient}\left\{\begin{matrix}30\\24\\20\end{matrix}\right.$$

The Sum whereof is 74

Then

Then say by the Golden Rule of Proportion,

If 74 come of 6000, what will come of $\left\{\begin{matrix}30\\24\\20\end{matrix}\right\}$ Answer $\left\{\begin{matrix}A & 2432.43\\B & 1945.95\\C & 1621.62\end{matrix}\right.$

The Sum —— 6000.00

## PROBL. XII.

*There are three Weights ABC, of which, the least Weight A, weighs 30 Pound, and the other two together do weigh seven times as much as A, and they are in proportion one to the other as 4 is to 5.*

THE Weight A weighing 30 Pound, the other two Weights together weighing 7 times A which is 30, must weigh 210 Pounds; and the Proportional Numbers 4 and 5 being added together do make 9. Then by the Rule of Proportion:

As 9, the Sum of the Proportional terms
Is to 210 the Sum of the two unknown Weights;
So is 5, the Greater Proportional Number,
To the Weight of the Greater Weight.

Wherefore, Multiply 210 by 5, the Product will be 1050, which divided by 9, gives in the Quotient $116\frac{2}{3}$ for the Weight of the bigger Weight; and that substracted from 210, the remainder is $93\frac{1}{3}$, for the lesser Weight, and so the three Weights are

$\left.\begin{matrix}A & 30\\B & 93\frac{1}{3}\\C & 116\frac{2}{3}\end{matrix}\right\}$ 240 the Weight of all three.

## PROBL. XIII.

*Two Travellers set out from two Towns which are 140 Miles distant, upon one and the same day; One travels 8 miles a day, the other 6: In how many days Travel will they meet each other?*

SUppose one D (or Day) for the time that they shall meet, in which time one would have travelled 8, and the other but 6 miles of the Journey, which together make 14 miles; whereas they should have been 140 miles: Wherefore, divide 140 by 14, the Quotient will be 10, and in so many days will they meet: For 10 times 8 is 80 Miles; and 10 times 6 is 60 Miles; which together make 140 Miles the whole Journey.

PROBL.

## PROBL. XIV.

*There is a* Ciftern *which hath Four* Cocks *of feveral Sifes, which Ciftern holds 8 Barrels of Water? If the firft or leaft Cock be opened, the Water will be 6 hours in running out: If the fecond Cock be only opened, the Water will iffue out in 4 hours: If the third be only opened, it will run out in 3 hours; and if the fourth and biggeft be only opened, it will run out in 2 hours: In what time will it run out, if all the four Cocks be fet running together?*

IF the leaft Cock will vent 8 Barrels (that is, all the Water) in 6 hours, the fecond would vent 12 Barrels in that time, the third 16, and the fourth 24 Barrels, in all 60 Barrels.

Here is now a Proportion between 60 Barrels and 8 Barrels, and between 6 hours and the time that all the Water will be vented in, if all the Cocks were opened: Wherefore fay,

*If 60 Barrels will run out in 6 hours; In what time will 8 Barrels run out?*

Multiply 6 by 8, the Product is 48, which fhould be divided by 60, but being it is lefs, the Quotient will be $\frac{48}{60}$ parts of an hour, or 48 Minutes, and in fuch time will all the Water run out, if all the four Cocks be fet open.

## PROBL. XV.

*A Man dies, and leaves his Wife big of her firft Child; and by Will bequeaths his Eftate in manner following: That if the Child his Wife then went withall fhould prove a Daughter, then his Wife fhould have two Thirds, and the Daughter one Third of his Eftate: If it fhould be a Son, then the Son was to have two Thirds, and the Mother one Third of his Eftate, which Eftate was 2600 Pound.——After the deceafe of the Father, the Mother was delivered of two Sons and one Daughter. How muft the Eftate be divided amongft them, according to the Will of the Father?*

BY the Teftators Will it is evident that for one Third that the *Daughter* had, the *Mother* was to have two Thirds; and the *Son* was to have double to the *Mother*. Then

| | | | *l.* | *s.* | *d.* |
|---|---|---|---|---|---|
| Suppofe the | Daughter | to have | 1 | 0 | 0 |
| | Mother | | 2 | 0 | 0 |
| | 1 Son | | 4 | 0 | 0 |
| | 2 Son | | 4 | 0 | 0 |
| | | The Sum | 11 | 0 | 0 |

This 11 Pound fhould be equivalent to 2600 Pound, wherefore divide 2600 by 11, and the Quotient will be 236 *l.* 7 *s.* 3 *d.* 1 *q.* for the Daughters fhare: And then will

The

| | | | l. | s. | d. | q. |
|---|---|---|---|---|---|---|
| The | Daughters | share be | 236 | 07 | 3 | 1 |
| | Mothers | | 472 | 14 | 6 | 2 |
| | 1 Sons | | 945 | 09 | 1 | 0 |
| | 2 Sons | | 945 | 09 | 1 | 1 |
| | | In all | 2600 | 00 | 0 | 0 |

Equal to the whole Eftate.

## PROBL. XVI.

*If there be 160 Pound (or 38400 Pence) to be diftributed among an equal number of Poor Prifoners, Lame Men, Widows and Children, fo that every Prifoner fhall have a Shilling, every Lame Man Six Pence, every Woman Four Pence, and every Child Three Pence: How many of fuch People will this Money relieve?*

THE Sum of Pence in 160 Pound being 38400, fet that down for a Dividend; then add 12 *d*, 6 *d*, 4 *d*, 3 *d* together, and they make 25, by which divide 38400, and the Quotient will be 1536; and fo many Perfons muft there be of each kind: For

| | | | l. | s. | d. | | |
|---|---|---|---|---|---|---|---|
| 1536 | Shillings | is | 76 | 16 | 0 | for | Prifoners. |
| | Sixpences | | 38 | 08 | 0 | | Lame Men. |
| | Groats | | 25 | 12 | 0 | | Women. |
| | Threepences | | 19 | 04 | 0 | | Children. |
| | | In all | 160 | 00 | 0 | | |

And now if you multiply 1536 by 4, the Product will be 6144, and fo many will be the whole number of Perfons to be relieved.

## PROBL XVII.

*What Number is that, which if you divide it by 9 there fhall remain 8, divide it by 8 there fhall remain 7, divide it by 7 there fhall remain 6, and fo by 6, 5, 4, 3 and 2, and being divided by 2 there fhall remain One?*

THere are feveral fuch Numbers to be found, and to find the leaft that is thus qualified, do thus, —— Set down all the nine Digits orderly one under another, and againft 1 fet a Cypher; then under 1 fet 2, and add 2 and 1 together, they make 3, which fet againft 2; then fay 3 times 3 is 9, and 2 over 3 is 11, fet 11 againft 3, and fay 4 times 11 is 44, and 3 over 4 is 47, fet 47 againft 4, and thus continuing you fhall find 725759 to ftand againft 9, and that is the leaft number that is capable to be divided as abovefaid, for the remainder fhall be always a Unite lefs than the number you divided by.

| | |
|---|---|
| 1 | 0 |
| 2 | 3 |
| 3 | 11 |
| 4 | 47 |
| 5 | 239 |
| 6 | 1439 |
| 7 | 10079 |
| 8 | 80639 |
| 9 | 725759 |

2519
5039
7559
10079
12599
15119
17639
20159

There are infinite other Numbers which have the like property, ſome of which are here inſerted. For,

| If any of thoſe Numbers be divided by | There will remain |
|---|---|
| 2 | 1 |
| 3 | 2 |
| 4 | 3 |
| 5 | 4 |
| 6 | 5 |
| 7 | 6 |
| 8 | 7 |
| 9 | 8 |

---

# CHAP. X.

## *Of Numbers thought upon.*

IF any Number be doubled, and that doubled be multiplied by 5, the Product of that Multiplication ſhall be the ſame with the Number firſt doubled, cutting off the Cypher which will always be on the Right hand: So 472 being doubled, makes 944, which multiplied by 5, produceth 4720, from which the Cypher being cut off there will remain the firſt Number 472.——And from hence it is uſual to bid one think any Number, then bid him double his number thought, and then multiply that double by 5, and give you the Product, which will be the very number he thought, with a Cypher before it; which omitted, you tell him what number he thought: But this way is ſo plain and obvious, that any one will diſcover it: I ſhall therefore ſhew ſome other ways not ſo liable to diſcovery.

### Firſt Way.

BID him which thinketh double his number thought, unto that double add 4, and multiply that Sum by 5, and unto that Product bid him add 12; then bid him tell you this laſt Product, unto which do you privately add a Cypher, and from the Sum ſubſtract 320, the remainder (two Cyphers being cut off) will be the number thought.

Example.

| | |
|---|---|
| The Number thought upon | 365 |
| The double thereof | 730 |
| To which add 4, it makes | 734 |
| That multiplied by 5, makes | 3670 |
| To which add 12, it makes | 3682 |

This laſt Product 3682 being given you, add unto it a Cypher, and it makes 36820, from which ſubſtract (always) 320, and the remainder will be 36500, from which the two Cyphers being taken, there will be left 365, the Number thought.

### The Second Way.

BID the Party that thinketh, break his number into any two parts; then bid him multiply each of thoſe parts by themſelves, and alſo the parts one by the other twice; then bid him add all thoſe four Products together, and give you the Sum of them; from which Sum do you Extract the Square Root, and that Root ſhall be the number thought.

Example.

Let the Number thought upon be 365; which let be broken into theſe two parts 221 and 144, which together make 365.

| | |
|---|---|
| Multiply 221 by 221, the Product is | 48841 |
| Multiply 144 by 144, the Product is | 20736 |
| Multiply 221 by 144, the Product is | 31824 |
| The ſame again | 31824 |
| The Sum of the four Products | 133225 |

The Square Root whereof is 365, the Number firſt thought upon.

### A Third Way.

LET any Perſon think (and ſet down) what Number he pleaſeth; then bid him multiply that Number, and their Products ſucceſſively by all the nine Digits; then bid him give you the laſt Product; which Product, if you divide it by 362880, the Quotient ſhall be the Number thought.

So if the Number thought (or ſet down) were 321, that Number multiplied by One (1) produceth only 321:

| | | | | | |
|---|---|---|---|---|---|
| And | 321 | Multiplied by | 2 | Produceth | 642 |
| | 642 | | 3 | | 1926 |
| | 1926 | | 4 | | 7704 |
| | 7704 | | 5 | | 38520 |
| | 38520 | | 6 | | 231120 |
| | 231120 | | 7 | | 1617840 |
| | 1617840 | | 8 | | 12942720 |
| | 12942720 | | 9 | | 116484480 |

Now

Now if you divide this laſt Product 116484480 (in any caſe) by 362880, the Quotient will be 321, equal to the Number thought.

### A Fourth Way.

LET any Perſon think (or ſet down) any Number, then let him multiply that Number by all the nine Digits; then let him add all the Products together, and give you the Sum of all the Products ſo added together; which Sum, if you divide (in any caſe) by 45, the Quotient will be the number thought. So

| | | | |
|---|---|---|---|
| | 1 | | 26 |
| | 2 | | 52 |
| Let the Number | 3 | | 78 |
| thought be 26. | 4 | | 104 |
| That Multiplied | 5 | Produceth | 130 |
| by | 6 | | 156 |
| | 7 | | 182 |
| | 8 | | 208 |
| | 9 | | 234 |
| | The Sum 45 | | The Sum 1170 |

Which Sum 1170 being divied by 45 (the Sum of the nine Digits) the Quotient will be 26, the Number thought.

### A Fifth Way.

BID a Perſon think (or ſet down) any Number, then bid him multiply the ſame Number by any other Number, what he pleaſes, (telling you what Number he multiplies by.) Then let him multiply that Product by what other Number he pleaſes (telling you what he multiplies by, as before.) And ſo continue multiplying three, four, or as many times as he pleaſes: In the mean time do you ſet down the Number by which he firſt multiplied, and multiply that Number by the ſecond Number that he multiplied by, and that Product by what he multiplied by the third time, and as many times as he multiplies; and when he hath done, bid him give you his laſt Product, which if you divide by your laſt Product, the Quotient will be the Number which he thought upon.

### Example.

Suppoſe the Number thought upon be 36, which he firſt Multiplies by 7, and the Product is 252, which he again will multiply by 3, and the Product is 756; which again he will multiply by 9, and the Product will be 6804; which laſt Product when he hath given you, then privately ſet down 7 (the Number that he firſt multiplied by) and multiply it by 3 (the ſecond Number he multiplied by) and the Product will be 21, which multiply by 9 (the third and laſt Number he multiplied by) and the Product will be 189, by which, if you divide his laſt Product 6804, the Quotient will be 36, the Number thought upon.

Otherwiſe,

If you bid him add all his Products together in one Sum, and give you the Sum of them, then do you add all your Products together, and by that divide his Sum, the Quotient will give the Number thought. So

| His | | | Your | | |
|---|---|---|---|---|---|
| His | First Product was | 252 | Your | First Product was | 7 |
| | Second | 756 | | Second | 21 |
| | Third | 6804 | | Third | 189 |
| | The Sum | 7812 | | | 217 |

Now if you divide 7812 (his Product) by 217 (your Product), the Quotient will be 36, as before.

VI. *If ſeveral perſons, three, four, five,* &c. *ſhould each of them think upon a ſeveral Number (under Ten), to tell what Number each perſon thought upon.*

BID the firſt perſon *double* the Number he thought, and add 5 to it, which Sum multiply by 5, and to it add 10; if from this Number you privately ſubtract (always) 35, the firſt figure of this remainder towards the left hand, ſhall be the Number that the firſt Party thought upon.

Example,

| | |
|---|---|
| Let one perſon think | 9 |
| The double thereof is | 18 |
| To which add 5, it makes | 23 |
| This 23 multiplied by 5, makes | 115 |
| To which add 10, it makes | 125 |
| From which 125, ſubtract | 35 |
| And the remainder is 90; from which the Cypher towards the right hand being omitted, the remainder is 9, the number thought. | |

Thus may you do if *One* perſon only think a number; but if *Two, Three,* or *Four* perſons think ſeverally, it will be much the ſame.

Example,

Suppoſe there were three perſons, A, B, and C, and each of them ſhould think theſe three numbers, A 4, B 9, and C 6.

| | |
|---|---|
| The Number which A thought is | 4 |
| Which doubled, makes | 8 |
| To which 5 added, it makes | 13 |
| Which multiplied by 5, produceth | 65 |
| To which add 10, and it makes | 75 |
| To this Product bid B privately add the Number he thought | 9 |
| It makes | 84 |
| Which bid him multiply by 10, it makes | 840 |
| To this Product let C privately add his Number thought, *viz.* | 6 |
| It makes | 846 |
| Which multiplied by 10, produceth | 8460 |

This

This being done, bid them give you this last Product 8460, from which do you privately substract 3500, and there will remain 4960; the Cypher being omitted, there will remain these three Digits, 4, 9, and 6, for the Numbers that A B and C severally thought upon.

*Note*, That if one person only Think, then (as before) substract from the last Product only 35; if two persons, substract 350; if three, 3500, &c.

VII. *There lies in a heap 132 (or any other number which you know) of Counters, or other Pieces of Money, or any other things whatsoever: Then if Three persons take each of them a certain number of Pieces out of the heap, unknown to you, to know how many Pieces each party took.*

LET the number of Counters in the heap be 132, and let the three persons be A, B, and C: Bid one of the Parties, as A, take from the heap 4, 8, 12, 16, 32, &c. or any other number that may be divided by 4, and keep them in his hand: Then bid B for every four Pieces that A took, let him take 7 Pieces: And bid C for every four Pieces that A took, take 13 Pieces: Which when they have done, tell what number of Counters are left, and substract them from the Number you laid down, and the remainder will be the Sum of Counters which all of them have in their hands, which number do you privately divide by 3, the Quotient shall be double to the Number which A took.

Example,

Let the Number of Counters which you laid down be 132. Then suppose that A took out 16, that is, four times 4, then B must take out 7 for every four that A took, which is four times 7, or 28; and C must take out 13 for every four that A took, and that is 4 times 13, or 52. This done, tell how many Counters there are left upon the Table, which you find to be 36; this substracted from the whole heap, which was 132, there will remain 96; and so many Pieces have A B and C in their hands; this Number 96 divide by 3, and the Quotient will be 32, the half of which is 16, and so many Pieces did A take; then B must have taken 28, and C 52.

VIII. *If there be two Pieces of Money, as a Ninepence and a Shilling, or any other two Pieces (provided one be Even, and the other Odd), let any person take one of them in one hand, and the other in his other hand, to tell in which hand the Ninepence (or Odd Piece) is, and in which the Shilling (or Even Piece) is.*

BID the Party that he double the Piece that he hath in his Left hand, and triple the Piece which he hath in his Right hand; then bid him add the two Numbers together, and ask him whether it be Even or Odd; if it be Even, the Shilling is in the Right hand; but if it be Odd, the Ninepence is in the Right hand.

Or,

If you bid the Party double the Piece which he hath in his Right hand, and triple that which he hath in his Left, and if the Number be Even, the Odd Piece is in the Right hand, and the Even in the Left.

IX. *If*

IX. *If any Number of Counters (suppose 9) or other Pieces of Money, Stones, or the like, be laid in a Row, to tell what Number (not exceeding the number of Pieces) any one thinketh upon.*

LAY Nine Counters on a row, (as in the Figure.)

B (over 2), A (over 6)

⊙ ⊙ ⊙ ⊙ ⊙ ⊙ ⊙ ⊙ ⊙
1 2 3 4 5 6 7 8 9

Then do you (privately) call that which lieth next your Left hand One, the next Two, the next Three, &c. then that towards your Right hand will be 9. Then bid any perſon think any number, not exceeding Nine, and then bid him lay his finger upon any of the Pieces; then (you knowing privately which Piece it is, whether the firſt, ſecond, third, or any other) add 9 privately to the Number of the Piece he laid his finger upon.

Thus if the Party ſhould think 2, and he ſhould lay his finger upon the Counter A, which is the ſixth, to this 6 add 9 ) the Number of Pieces in all) and it makes 15; then bid the Party count from the Number which he thought upon (beginning at the Counter A) backwards, till he make his number thought on 15, which Number 15 will end at the Counter B, which is the ſecond Counter, and denotes the Number he thought on, to be 2.

The like may be done with any Number more or leſs than 9; only remember, that as now you added 9, you muſt always add the Number of the Counters or Pieces you laid down, whether 6, 10, 15, &c.

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## CHAP. XI.

*A Plain and Eaſie Method of Extracting the* Square Root *of any Number (how great ſoever) without the help of* Multiplication *or* Diviſion.

THIS Method of *Extracting* of the *Square Root*, I cannot but attribute to Sir *Sam. Moreland*, Baronet, altho it doth not much differ from the manner of *Extraction* by *Nepier's Bones*: For as thoſe *Rods* which my Lord *Nepier* (the Inventor of them) calls *Rabdologia*, Sir *Samuel* doth reduce the Poſition of them into ſeveral *Tables*, which he calls *Tariffa's*. The manner of making or preparing whereof I ſhall here ſhew:

How

## *How to make a* Tariffa *for One or more* Figures, *that is, for any Digit, or mixt Number.*

*Example*: Suppose I would make a *Tariffa* for the Digit Number 4. As in Table ( or *Tariffa* ) I.

First, Set down the *Nine Digits* orderly, in a Column towards the left hand, and in Figures bigger than ordinary, that they may take up the space of two lines of smaller Figures.

Secondly, Against the Digit 1, more to the right hand, and at the top or upper part of the line set 4, the Figure for which the *Tariffa* is to be made.

Thirdly, Double 4, and it makes 8, which set under 4, against the Digit 2, and at the upper part of the Line.

Fourthly, Add 4 to 8, and they make 12, which set against the Digit 3: Also to 12 add 4, it makes 16, which set against the Digit 4; to which add 4, and it makes 20, which set against the Digit 5, and so continually adding 4, you shall have 36 to stand against the Digit 9; for 4 times 9 is 36.

Fifthly, In a Column yet one place forward towards the Right hand, set the *Squares* of the several *Digits*; as against 1 set 1, against 2 set 4, against 3 set 9, against 4 set 16, and against 9 you will have 81: And thus is your *First Tariffa* for the single Figure 4 finished.

Now to make a *Tariffa* for two or more Figures, the same method is still to be observed. As for

*Example*: Suppose I would make a *Tariffa* for 46.

First, In a Column towards the Left hand set down the Nine Digits orderly, and in a bigger Figure.

Secondly, Set your Number to be *Tariffed* 46, against 1, as in the second *Tariffa*.

Thirdly, Double 46, and it makes 92, which set against 2; then add 92 to 46, and they make 138, which set against 3; and so by the continual addition of 46, you shall find 414 to stand against the Digit 9, for 9 times 46 is 414.

Lastly, In a Column yet more to the Right hand, set the *Squares* of the Nine *Digits*; as against 1 set 1; against 2 set 4; against 3 set 9; against 4 set 16, as in the first *Tariffa*.

And in the same manner may you make a *Tariffa* for any number, how great soever by the directions of the two foregoing *Examples*; and as is done for the number 468 in the *Third Tariffa*; and for 4684 in *Fourth Tariffa*; &c.

---

| Digits. | First Teneriffa. | | Squares of the Digits. |
|---|---|---|---|
| 1 | | 4 | 1 |
| 2 | | 8 | 4 |
| 3 | 1 | 2 | 9 |
| 4 | 1 | 6<br>1 | 6 |
| 5 | 2 | 0<br>2 | 5 |
| 6 | 2 | 4<br>3 | 6 |
| 7 | 2 | 8<br>4 | 9 |
| 8 | 3 | 2<br>6 | 4 |
| 9 | 3 | 6<br>8 | 1 |

| Digits. | Second Tariffa. | | | Squares of the Digits. |
|---|---|---|---|---|
| 1 | | 4 | 6 | 1 |
| 2 | | 9 | 2 | 4 |
| 3 | 1 | 3 | 8 | 9 |
| 4 | 1 | 8 | 4<br>1 | 6 |
| 5 | 2 | 3 | 0<br>2 | 5 |
| 6 | 2 | 7 | 6<br>3 | 6 |
| 7 | 3 | 2 | 2<br>4 | 9 |
| 8 | 3 | 6 | 8<br>6 | 4 |
| 9 | 4 | 1 | 4<br>8 | 1 |

| Digits. | Third Tariffa. | | | | Squares of the Digits. |
|---|---|---|---|---|---|
| 1 | | 4 | 6 | 8 | 1 |
| 2 | | 9 | 3 | 6 | 4 |
| 3 | 1 | 4 | 0 | 4 | 9 |
| 4 | 1 | 8 | 7 | 2<br>1 | 6 |
| 5 | 2 | 3 | 4 | 0<br>2 | 5 |
| 6 | 2 | 8 | 0 | 8<br>3 | 6 |
| 7 | 3 | 2 | 7 | 6<br>4 | 9 |
| 8 | 3 | 7 | 4 | 4<br>6 | 4 |
| 9 | 4 | 2 | 1 | 2<br>8 | 1 |

| Digits. | Fourth Tariffa. | | | | | Squares of the Digits. |
|---|---|---|---|---|---|---|
| 1 | | 4 | 6 | 8 | 4 | 1 |
| 2 | | 9 | 3 | 6 | 8 | 4 |
| 3 | 1 | 4 | 0 | 5 | 2 | 9 |
| 4 | 1 | 8 | 7 | 3 | 6<br>1 | 6 |
| 5 | 2 | 3 | 4 | 2 | 0<br>2 | 5 |
| 6 | 2 | 8 | 1 | 0 | 4<br>3 | 6 |
| 7 | 3 | 2 | 7 | 8 | 8<br>4 | 9 |
| 8 | 3 | 7 | 4 | 7 | 2<br>6 | 4 |
| 9 | 4 | 2 | 1 | 5 | 6<br>8 | 1 |

## *How to* Extract *the* Square Root *of any* Number.

LET 548777476 be a Number given, and let the Square Root thereof be required

First set down the Number, and make a Prick over the first figure thereof towards the right hand, and so over every second figure, as is usual in Vulgar *Arithmetick*, and then will the Number given being so Pointed, stand thus,

$$\dot{5}4\dot{8}7\dot{7}7\dot{4}7\dot{6}$$

And there being five Points, it shews that the *Root* thereof will consist of *Five Figures*, whereof to begin your *Extraction*, find the nearest *Square Number* to 5, the figure under the last Point, and that is 4, the *Root* whereof is 2, put 2 into the *Quotient*, and set the *Square* thereof 4, under 5, and substracting 4 from 5, there will remain 1, to which 1 bring down the two figures belonging to the *Second Point*, namely 4 and 8, and then it will be 148, and the work will stand thus,

$$\begin{array}{l} \dot{5}4\dot{8}7\dot{7}7\dot{4}7\dot{6}\ (2 \\ 4 \\ \hline 148 \end{array}$$

Then double 2, the figure in the *Quotient*, and it makes 4; for which figure 4 make a *Tariffa*, as is before taught, (as the *First Tariffa* is) and in

in that *Tariffa* find the nearest number to 148, which is lesser, and you shall find that number to be 129, against which (in the Colume of *Digits*) stands 3, put 3 in the *Quotient*, and substract 129 from 148, and the Remainder will be 19; to which bring down the two figures belonging to the Third Point, namely 77, and then the Number will be 1977, and the work will stand thus,

```
548777476 (23
4
———
148
129
———
 1977
```

Then double the two figures in the *Quotient*, and they make 46, for which number 46 make a *Tariffa* (as is the *Second Tariffa* beforegoing); and in that *Tariffa* find the nearest number less than 1977, which you will there find to be 1856, against which stands the *Digit* 4; put 4 in the *Quotient*, and substract 1856 from 1977, and the Remainder will be 121, to which bring down the two figures belonging to the fourth Point, namely 74, and then the Number will be 12174, and the work will stand thus,

```
548777476 (23
4
———
148
129
———
 1977
 1856
———
  12174
```

Then double the three Figures in the *Quotient*, and they make 468; for which Number make a *Tariffa* (as is the *Third Tariffa* beforegoing), and in that *Tariffa* find the nearest Number, which is lesser, to 12174, which I find there to be 9364, against which stands the Digit 2; put 2 in the *Quotient*, and substract 9364 from 12174, and the Remainder will be 2810, to which bring down the two figures belonging to the last Point, namely 76, and then the number will be 281076, and then the work will stand thus,

```
548777476 (234
4
———
148
129
———
 1977
 1856
———
  12174
   9364
———
  281076
```

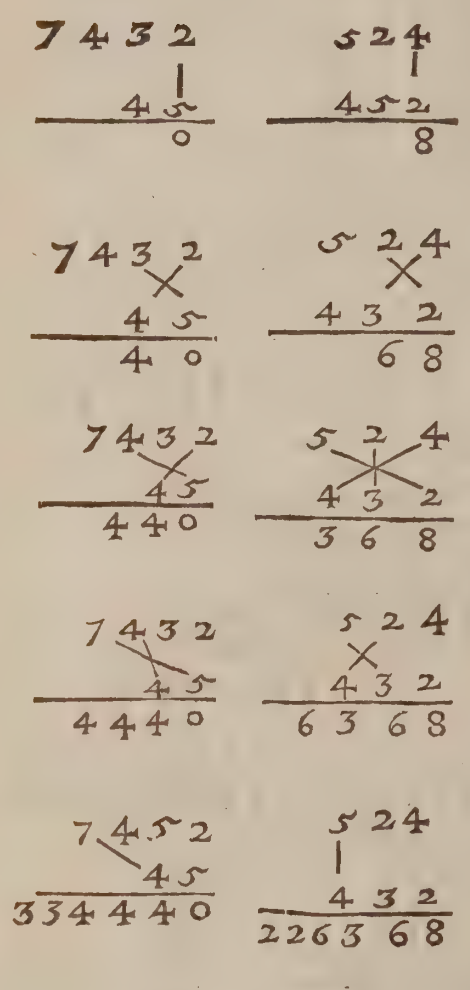
This done, Double the four figures in the *Quotient*, and they make 4684; for which number make a *Tariffa*, as is the *Fourth*, in the foregoing *Examples*; and in it find the nearest number to 281076, and in it you shall find the very number to stand against the Digit 6: Wherefore put 6 in the *Quotient*, and substract 281076, from 281076, and there will remain nothing; which shews that the given number 548777476 is an exact *Square Number*, and that 23426 is the *Root* thereof; and so the whole Work being ended, it will stand as followeth.

```
548777476 (23426
4
———
148
129
———
 1977
 1856
———
  12174
   9364
———
  281076
  281076
———
  000000
```

# CHAP. XII.

*A Brief and Compendious Way of* Multiplication, *wherein the* Product *is given at once, without ſeveral Workings, or writing down any other* Figures *but the* Product *it ſelf.*

I. *Example.* LET it be requred to multiply 7432, by 45. Set down the Numbers as in the *Margent.* Then,



Example I. Example II.

1. Multiply as the line directs you; ſay, 5 times 2 is 10, place 0 under Unites, and carry 1 in mind.

2. Say 5 times 3 is 15, and 4 times 2 is 8, which added together, with 1 in mind, makes 24, ſet down 4 in the next place on the left hand, and carry 2 in mind.

3. Say 5 times 4 is 20, and 4 times 3 is 12, which added together, with 2 in mind, makes 34, place the odd 4 in the next place, and carry 3 in mind.

4. Say 5 times 7 is 35, and 4 times 4 is 16, which added together, with 3 in mind, makes 54, ſet down 4 in the next place, and carry 5 in mind.

Laſtly, Say 4 times 7 is 28, and 3 in mind is 33, which ſet down, and the work is at an end: And the Product of 7452 multiplied by 45, is 334440: As in the Margent.

II. *Example*, Multiply, 524 by 452.

1. Set the Numbers down, as in the Margent, and ſay (as the line directs) 2 times 4 is 8; ſet 8 in the place of Unites under 2.

2. Say 2 times 2 is 4, and 3 times 4 is 12, which added together make 16, place 6 under 3, and bear 1 in mind.

3. Say 2 times 5 is 10, and 3 times 2 is 6, and 4 times 4 is 16, which added together with 1 in mind, makes 33, place 3 under 4, and bear 3 in mind.

4. Say 3 times 5 is 15, and 4 times 2 is 8, which added together, with 3 in mind, makes 26, place 6 before 3, and bear 2 in mind.

Laſtly, Say 4 times 5 is 20, and 2 in mind makes 22, which ſet down, and the work is at an end: And the Product of 524 multiplied by 432, will be 226368, as in the Margent.

CHAP.

# CHAP. XIII.

## Of Ceres and Virginum.

IN ſome Ancient, and in ſome late Writers of *Arithmetick* alſo, I find a *Rule* called *Ceres* and *Virginum*, which teacheth only how to reſolve *Merry* or *Sporting Queſtions*, to puzzle young *Practitioners* in *Numbers*: And in regard that this *Book* is fraught with matters *Recreative*, I ſhall here inſert it, with ſome Reflections upon it: And this *Rule* will be made appear beſt, by the Solution of certain *Queſtions* as properly belong to it; as ſuch as here follow.

### Queſtion I.

*A Lady's* Caterer *bought* Eight Birds *of two ſorts, namely* Geeſe *and* Hens, *for* 20 Shillings: *The* Geeſe *coſt* 4 ſhillings *apiece, and the* Hens 2 ſhillings *apiece: How many did he buy of each ſort?*

MUltiply the whole number of *Birds*, viz. 8, into the *Leaſt Price*, 2 *s.* the *Product* will be 16, which take from the whole number of *Birds*, viz. 20, there will remain 4 for a *Dividend*, which muſt be divided by the difference of the *Prices* of the two ſorts of *Birds*, namely, by 2, and the *Quotient* will be 2 for the number of *Geeſe*; then muſt the *Hens* be 6. And ſo

2 Geeſe at 4 *s.* is —— 8 *s.*
6 Hens at 2 *s.* is —— 12 *s.*

In all 8 In all 20.

### Queſtion II.

*There were One and Twenty perſons in Company, ſome* Men, *ſome* Women, *and ſome* Children; *and amongſt them they ſpent* 26 Shillings, *and ſo, that every* Man *ſpent* 2 *Shillings, every* Woman 1 *Shilling, and every* Child 6 *Pence: How many muſt there be of each ſort?*

To reſolve this or the like, this is the RULE:

*Multiply the Number of Perſons by the leaſt Expence, and take the Product of it from the whole Expence, the reſt ſhall be the Dividend; which divided by the difference between the Greateſt and Leaſt particular Expence, the Quotient is a Number, which the number of Men (or they which ſpend moſt) comes near to, but cannot exceed. ——Or if the ſaid Dividend be divided by the Sum of the Greateſt and Leaſt Expence, the Quotient is a Number, than which the number of men, (or thoſe which ſpend moſt) cannot be much leſs.*

SO in this *Queſtion*, 21 *Perſons* multiplied by 6 Pence (the leaſt Expence), the Product is $10\frac{1}{2}$, which taken from 26 (the whole *Expence*) the Remainder is $15\frac{1}{2}$ for the Dividend; and then taking $\frac{1}{2}$ from 2, there reſts $1\frac{1}{2}$ for the Diviſor, and the *Quotient* is $\frac{31}{3}$, which is ſomething more than 10; the number of men therefore muſt be but 9.

Then turn the *Dividend* and the *Diviſor* both into whole Numbers, by multiplying them into the common *Denominator* 2, ſo they being reduced, will be 31 and 3, as before is ſeen in the Quotient.

Multiply the *Diviſor* 3 by 9 (which is the number of *Men*) the *Product* is 27, which taken from 31 (which is the reduced *Dividend*) the remainder is 4 for the Number of *Women*; and then the *Children* muſt be 8; as in the firſt Example.

| | | | s. |
|---|---|---|---|
| First | 9 | Men, at 2 s. each | 18 |
| | 4 | Women, at 1 s. each, is | 4 |
| | 8 | Children, at 6 d. each | 4 |
| | In all 21 Perſons. | In all 26 s. expended. | |

But the *number* of *Men* may be alſo but 8, which multiplied by the reduced Diviſor 3, it produceth 24, which taken from 31, the remainder is 7 for the *Women*; and then the *Children* muſt be 6: As in this ſecond Example.

| | | | s. |
|---|---|---|---|
| Second | 8 | Men, at 2 s. each | 16 |
| | 7 | Women, at 1 s. each | 7 |
| | 6 | Children, at 6 d. each | 3 |
| | In all 21 Perſons. | In all 26 s. expended. | |

Or the number of Men may be 7, which multiplied by 3, produceth 21, which taken from 31, there remains 10 for the Women, and then the Children muſt be 4, as in this third Example.

| | | | s. |
|---|---|---|---|
| Thirdly | 7 | Men, at 2 s. each | 14 |
| | 10 | Women, at 1 s. each | 10 |
| | 4 | Children, at 6 d. each | 2 |
| | In all 21 Perſons. | In all 26 s. expended. | |

By what is here delivered in this ſecond Queſtion, it is plain that it is capable of ſeveral Solutions, and all of them true.

But further, The number of Men may be 10, and not more; for if you put them 11, that multiplied by 3 produceth 33, which is greater than 31 from whence it ſhould be taken: But they may be 10, and then there is only One Woman and 10 Children; and this confirms the former part of the Rule.

Now for the later part of it: If the Dividend 31, be divided by the Sum of the two Extreams (reduced by doubling as the Dividend is) 4, the Quotient will be $7\frac{3}{4}$, and the Men may be 7 as hath been ſhewed; but they may be alſo but 6, and fewer they cannot be: As 6 Men, 13 Women, and 2 Children: For if you put the Men Five, that multiplied by 3, produceth 15, which taken from 31, there remains 16 for the *Women*, and ſo there ſhould be no *Children*, which is contrary to the Suppoſition.

And further, Becauſe the Quotient was $7\frac{3}{4}$, the number of Men might be ſo (if pure Arithmetical Diviſion be only regarded.) And then the number of Women are $7\frac{3}{4}$, and the Children $5\frac{1}{2}$, as in this Example.

$7\frac{3}{4}$ Men,

| | | s. | d. |
|---|---|---|---|
| $7\frac{3}{4}$ | Men, at 2 *s.* each | 15 | 6 |
| $7\frac{3}{4}$ | Women, at 1 *s.* each | 7 | 9 |
| $5\frac{1}{2}$ | Children at 6 *d.* each | 2 | 9 |
| In all 21 | Perſons | In all 26 | 0 expended. |

## *Queſtion* III.

*There is* 900 l. *to be diſtributed by the Will of a Deceaſed Friend, to* 30 *Perſons of three ſeveral Qualifications, as* Miniſters, Lame Soldiers, *and* Poor Tradeſmen; *ſo that each* Miniſter *may have* 60 l. *each* Soldier 40 l. *and each* Tradeſman 20 l. *How many Perſons of each Qualification muſt (or may) there be?*

MUltiply (according to the *Rule*) 30, the *Number of Perſons*, by 20, the *leaſt Share*, the Product is 600, which taken from 900, the whole *Legacy*, there remains 300 for the Dividend; and 20, the leaſt ſhare, taken from 60, the greateſt ſhare, leaves 40 for a *Diviſor*; and ſo the *Quotient* will be $7\frac{1}{2}$, and more the *Miniſters* cannot be: Alſo add 60 and 20 (the *greateſt* and *leaſt Shares* together) their Sum is 80, by which divide 300, and the Quotient will be $3\frac{3}{4}$, and much fewer the *Miniſters* cannot be

Not to ſtand upon the *Fractions* (in the dividing of Men)

| The | | may be either | | | | | |
|---|---|---|---|---|---|---|---|
| | Miniſters | | 7. | 6. | 5. | 4. | 3. |
| | Soldiers | | 1. | 3. | 5. | 7. | 9. |
| | Tradeſmen | | 22. | 21. | 20. | 19. | 18. |

$\underbrace{\qquad\qquad\qquad\qquad}_{30}$

That the *Miniſters* cannot (in whole Numbers) be more than 7 or leſs than 3, may thus be proved. ——Firſt, Let them be 8, then 8 times 40 is 320 which is more than 300, from which it ſhould be taken. ——Secondly, Let them be 2, then 2 times 40 is 80, out of 300 there remains 220, which divided by 20, gives in the Quotient 11 for the *Soldiers*; ſo the *Miniſters* and *Soldiers* being 13, the *Tradeſmen* muſt be 17.

But,

| | l. |
|---|---|
| 2 Miniſters, at 60 *l.* each, is | 120 |
| 11 Soldiers, at 40 *l.* each, is | 440 |
| 17 Tradeſmen, at 20 *l.* each, is | 340 |
| In all | 900 |

Queſtion

## Queſtion IV.

*If there be Ten Perſons of Four ſeveral Countries,* Engliſh, Dutch, French *and* Spaniards, *to pay a Debt of* 1000 *l. ſo that every* Engliſh-man *pays* 50 l. *every* French-man 70 l. *every* Dutch-man 130 l. *and every* Spaniard 150 l. *How many is there of each* Country?

THE *Dividend* (according to the former Rule) is 500: Now to find the *Diviſor*, take his Sum that pays leaſt (namely 50 *l.*) out of each of the other three, 150, 130, and 70, and the remains will be 100, 80 and 20.

And the *Firſt* and *Laſt*, viz. 120 for the *Diviſor*; the Quotient will be 4 $\frac{2}{12}$, and the *Spaniards* cannot be more.

Secondly, Add the firſt and ſecond together, *viz.* 180, the Quotient is 2 $\frac{14}{18}$; and the *Spaniards* cannot be leſs. That is,

The *Spaniards* cannot be much more than 4, or leſs than 2: And therefore, ſeeing any one Solution will ſerve,

Let the *Spaniards* be 3, and by that multiply 100, and take the Product out of 500, there remains 200 for a ſecond *Dividend*, which divided by the ſecond remain, 80, the Quotient is 2 $\frac{1}{2}$, therefore the *Dutch-men* are 2, which multiplied by 80, makes 160; take that out of 200, there remains 40 for a third *Dividend*, which divided by the third remain, 20, the *Quotient* is 2 for the *French-men* alſo, and conſequently the *Engliſh-men* muſt be 3, becauſe all of them are 10: But the *Spaniards* may be alſo 4 or 2.

Example.

| | | *l.* |
|---|---|---|
| 4 | Spaniards, at 150 *l.* each | 600 |
| 1 | Dutch-man, at 130 *l.* | 130 |
| 1 | French-man, at 70 *l.* | 70 |
| 4 | Engliſh-men, at 50 *l.* each | 200 |
| In all 10 | | In all 1000 |

Again,

| | | |
|---|---|---|
| 2 | Spaniards, at 150 *l.* each | 300 |
| 3 | Dutch, at 130 *l.* each | 390 |
| 3 | French-men, at 70 *l.* each | 210 |
| 2 | Engliſh, at 50 *l.* each | 100 |
| In all 10 | | In all 1000 |

The Reaſon why the *Spaniards* and *Engliſh*, as alſo the *Dutch* and *French*, are equal in number, is, becauſe their Payments differ equally from 100, which is the *Mean Sum* with which 10 Men ſhould pay 1000 Pound.

Queſtion

### Question V.

*If one should buy* 12 *Loaves of Bread for* 12 *Pence; so that some might be Twopenny, some Penny, some Halfpenny, and some Farthing Loaves; and it be required to know how many he must buy of each sort?*

NOW, Because of 12 *Loaves* for 12 *Pence*, the *Mean Price* is 1, but one of the Particulars being also 1, there should be no *Penny Loaves*, because there is no difference betwixt the *Mean Price* and *One Penny*.

But it may be found by this Rule to be either

| | |
|---|---|
| 4 Twopenny Loaves, | 8 Pence |
| 2 Penny Loaves, | 2 Pence |
| 2 Halfpenny Loaves, | 1 Penny |
| 4 Farthing Loaves, | 1 Penny |
| In all 12 Loaves | In all 12 Pence |

Or else it may be

| | | |
|---|---|---|
| 3 Twopenny Loaves, | 6 | Pence |
| 4 Penny Loaves, | 4 | q |
| 3 Halfpenny Loaves, | 1 | 2 |
| 2 Farthing Loaves, | 0 | 2 |
| In all 12 Loaves. | In all 12 | 0 Pence |

And so much for this Rule.

---

## CHAP. XIV.

## Of Numerical Devices.

*If any Person write down any three Digits (as 6, 8, 7) and under them make Nine other Digits set in Rank and File; and under them you set Nine other Digits in the same order; how to know, and set down the Agregate or total Sum of all the* 18 *Digits and the three first Figures, being added together; before any of the* 18 *Digits be set down.*

LET the three Figures first set down be 6, 8, 7, under them draw a Line, and under the Line make nine Pricks; and under them draw another Line, and under it make nine other Pricks, and a Line under them, as is done in the Margin: This done (always) substract 3 from the Digit standing in the place of Unity, in this case 7, and the remainder is 4; then, upon a piece of Paper (by the bye) write down 6, 8, 4 instead of 6, 8, 7, and to the left hand of it set 3, instead of the 3 which you abated from the 7; so will your Number be 3684; and that will be the Aggregate or Sum of the 18 Digits, and the three uppermost Figures, all being added together: As in the following Example.

| | | |
|---|---|---|
| 6 | 8 | 7 |
| . | . | . |
| . | . | . |
| . | . | . |
| . | . | . |
| . | . | . |
| . | . | . |

Having

687
748
631
254
251
368
745
3684

Having ſet down the three Figures 687, and drawn under them a Line, and made 18 Points and Lines as in the Margin above, bid any Perſon about you write any nine Digits upon the nine upper Pricks, and you will write nine other upon the nine other Pricks below; all which being added together, ſhall make 3684.—Suppoſe (as in the Margin) on the uppermoſt nine Pricks be written 748—631—254; then do you, upon the nine Pricks under, write the Complements of thoſe nine Figures to Nine; as for his three firſt 748 do you write 251, for 631 write 368, and for 254 write 745; all which added together, will make 3684, the Sum you firſt ſet down before any of the 18 figures were written.

422
325
769
134
674
230
865
3419

*Example* 2. But if the Digit in the place of Unity be leſs than 3, as in theſe three figures 422, you muſt take 3 from 12, and there will remain 9, which ſet down; and (becauſe you borrowed 10) take 1 from 2, and there remains 1, and 4 is the ſame 4, before which put 3 for the 3 which you borrowed, and then the Sum is 3419, which you tell beforehand will be the Aggregate or Sum of all the Addition, as in the Margent is plain.

The like may be done by 4, 5, 6 figures, by obſerving the ſame method, by abating of ſo many Unites from the place of Unity, and reſtoring again in the place of Thouſands or Ten thouſands, *&c.* As in theſe Examples,

| | |
|---|---|
| 6785 | 25798 |
| 2368 | 20368 |
| 7521 | 42600 |
| 8372 | 53411 |
| 6154 | 27069 |
| | 83502 |
| 7631 | 79631 |
| 2478 | 57399 |
| 1627 | 41588 |
| 3845 | 72930 |
| | 16497 |
| 46781 | 525793 |

*If Three of a ſort of the Five Odd Digit Numbers be ſet in Rank and File, as in the Margent, and it be required of any Five of theſe Odd Digits to make the juſt Number* 20, *How may that be done?*

| | |
|---|---|
| 1 1 1 | 6 6 6 |
| 3 3 3 | L L L |
| 5 5 5 | S S S |
| 7 7 7 | Ɛ Ɛ Ɛ |
| 9 9 9 | I I I |

In the Performance of this there is a Falacy; for no five odd Numbers taken howſoever, can make up that Number; wherefore they do invert the Numbers, by turning of the Paper upon which they are written, upſide down, and then the three Nines become three Sixes; and ſo 3 times 6 is 18, and two of the Ones makes 20, as in the other Margent.

GEO-

# Geometrical RECREATIONS.

## CHAP. I.

## Of Geometrical *Definitions*, and Practical *Problems.*

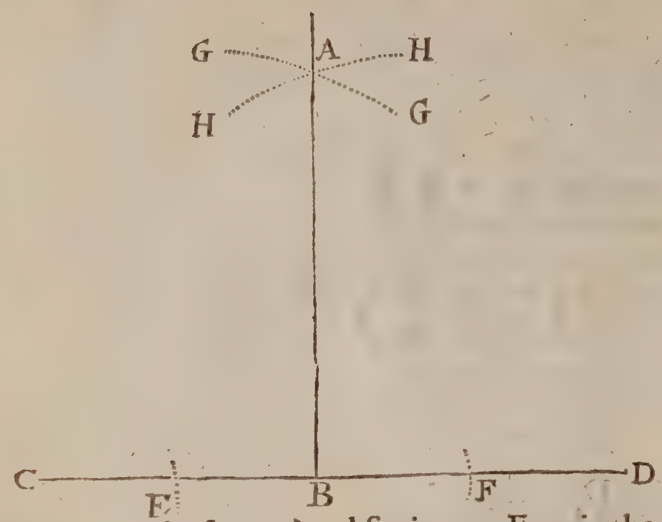
### PROBL. I.

*From a* Point, *in a* Right Line *given, to erect another* Right Line *which ſhall be* Perpendicular *to the* Right Line *given.*

*Definition* I.] A *Point* is that which hath no Parts, and is the leaſt imaginary thing that can be conceived in the mind: As this *Point* or *Prick* noted with Z . Z

*Definition* 2.] A *Right Line* is a Line drawn equally between two given *Points*, and is the ſhorteſt diſtance between them, as is this *Line* X Y, which is the ſhorteſt diſtance between the two *Points* X and Y. X ———— Y.

*Definition* 3.] A *Right Line* is ſaid to be *Perpendicular* to another *Right Line*, when it maketh the *Angles* on either ſide of the erected Line equal; that is, ſo that the *erected Line* inclines not either to the *Right hand*, or to the *Left*, but ſtandeth upright upon the *Line* from which it is erected: As in the *Right Line* A B, is ſaid to be *Perpendicular* to the *Right Line* C D, upon which it is erected, for that it inclineth neither to the *Right* or *Left* hand; and becauſe the *Angles* on either ſide thereof are equal; namely, The *Angle* A B C on the one ſide, equal to the *Angle* A B D on the other ſide; either of which Angles are *Right Angles*, and the *Right Line* A B ſo ſtanding is *Perpendicular* to the *Right Line* C D upon which it is erected.




*Practice.*] LET the Right Line given be C D, and let it be required to erect another Right Line which ſhall be Perpendicular thereunto, from the Point B.

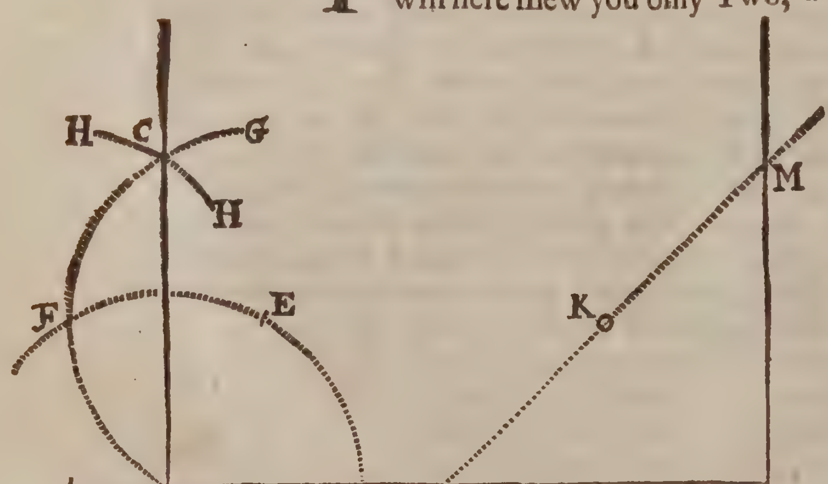
Open your Compaſſes to any convenient ſmall diſtance, and ſetting one Foot in the Point B, with the other make the two ſmall marks E and F, on either ſide, equidiſtant from the given Point B. ——This done, Open the Compaſſes again to any convenient diſtance (greater than the former) and ſetting one Foot in the Point E, with the other deſcribe the obſcure Arch G G (over the given Point B as near as you can gueſs). ——Again; (The Compaſſes being ſtill open at the ſame diſtance) ſet one Foot in the Point F, and with the other deſcribe another obſcure Arch H H, croſſing the former in the Point A: So is A a Point found, through which if you draw a Right Line from the given Point B, that Right Line A B, ſhall be Perpendicular to the given Right Line C D, and from the Point B, which was required to be done: And the Angle A B D, on the one ſide thereof, is equal to the Angle A B C, on the other ſide; and both of them are Right (or Square) Angles.

¶ *Note*, An Angle is always ſignified by Three Letters, as a Point is by One; the middlemoſt of which Three repreſenteth the Angular Point, as in this Caſe the Letter B. —— B being the Angular Point, and the Lines A B and B C the ſides containing the Angle B.

## PROBL. II.

*How to erect a Perpendicular, when the given Point is in (or near) the end of the given Right Line.*

*Practice.*] THERE are ſeveral ways to effect this; of which I will here ſhew you only Two, as being the beſt.




Let A B be a Line given, and from the Point A, towards the end thereof, let it be required to erect the Perpendicular A C. —— Firſt, Open the Compaſſes to any ſmall diſtance, and ſetting one Foot in the given Point A, with the other deſcribe an Arch (or part) of a Circle, F E D, —And (keeping

ing the Compaſſes ſtill at the ſame diſtance) ſet one Foot in D, and make a mark in the Arch at E, and ſetting one Foot in E, with the other deſcribe another Arch of a Circle A F G, croſſing the firſt Arch in F. Again, Set one Foot in F, and with the other deſcribe the ſmall Arch H H, croſſing the former in the Point C, through which Point C, draw a Line from the given Point A, and that Line ſhall be Perpendicular to the given Line A B, and drawn from the Point A, as was required.

*A Second Way.*

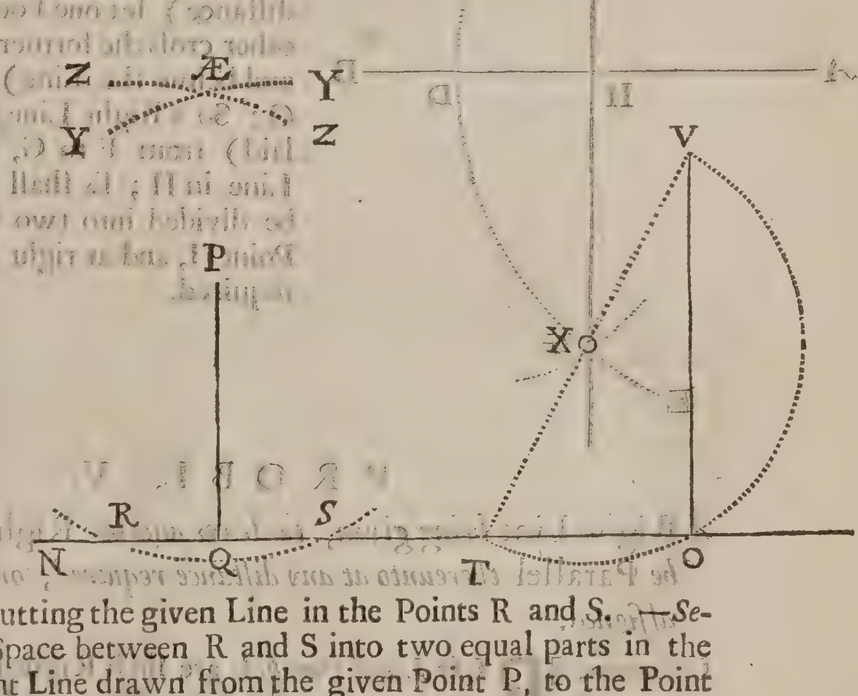
Let B (the extreme end of the given Line) be the Point given. —— Open the Compaſſes to any convenient diſtance, and ſetting one Foot in B, pitch down the other Foot at adventure in the Point K; ſo one Foot reſting in K, turn the other about till it croſs the given Line A B in L, and draw the right Line L K at length, and ſet the ſame diſtance K, L, (at which the Compaſſes already ſtand) from K to M; ſo a Line drawn from B through M, ſhall be Perpendicular to A B, and from the given Point B, as was required.

## PROBL. III.

*From a* Point, *above, to let a* Perpendicular *fall upon a Right Line under it.*

IN this there are two Caſes, —— *Firſt*, when the given Point above, is over, (or near) the *middle* of the given Line. And —— *Secondly*, When the given Point is juſt (or near) over the *End* of the given Line.

*Practice.*] IN the firſt Caſe, Let N O be a right Line given, and from the Point P (over it) let it be required to let fall the Perpendicular P Q. *Firſt*, Open the Compaſſes to any convenient diſtance greater than the diſtance between P and Q; and ſetting one Foot in P, with the other draw an obſcure Arch of a Circle, cutting the given Line in the Points R and S. —— *Secondly*, Divide the Space between R and S into two equal parts in the Point Q; ſo a Right Line drawn from the given Point P, to the Point Q, ſhall be Perpendicular to the Line N O.



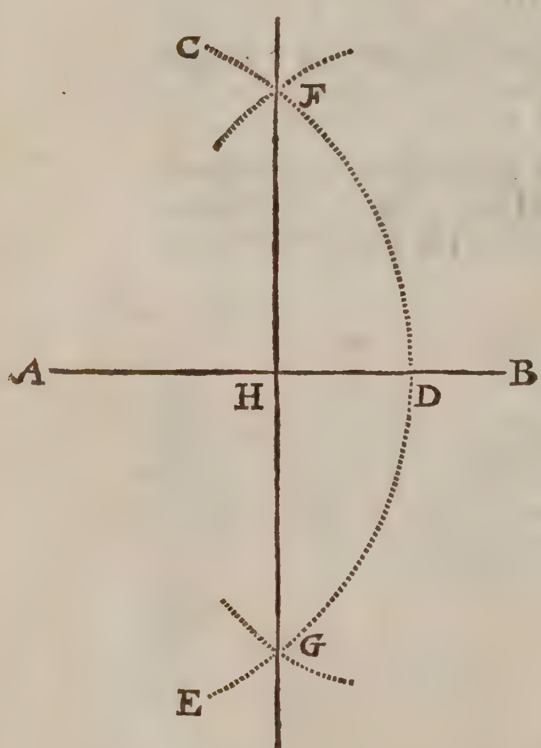

 Note,

*Note,* To avoid the dividing of the ſpace R S into two equal parts, to find the Point Q; if you have room (either above or beneath your Line) you may ſet one Foot in S, and opening the Compaſſes to any convenient diſtance, make the Arch Y Y, and removing the Compaſſes to R, make the Arch Z Z, croſſing the former in Æ, ſo a Line drawn through Æ and P, ſhall be Perpendicular to N O.

*In the ſecond Caſe,* Let V be the Point given; —— *Firſt,* From any part of the given Line N O, as from T, draw a Right Line to the given Point V, which divide into two equal parts in X. —— Secondly, Set one Foot of the Compaſſes in X, and with the diſtance X T deſcribe the Arch (or Semicircle) V O T, cutting the given Line N O in O, ſo ſhall O be the Point, to which from the given Point V, if you draw a right Line, it ſhall be a Perpendicular to the Line N O, and from the Point V, as was required.

## PROBL. IV.

*To divide a Right Line into Two equal Parts, and at Right (or Square) Angles.*



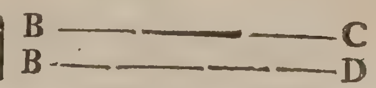

LET A B be a Line given, to be ſo divided. — Take in your Compaſſes the Length of the given Line A B; or (if that be too long) to any other diſtance greater than half the length thereof; and ſetting one Foot in the end A, with the other draw the Arch C D E.—— Secondly, (the Compaſſes being open at the ſame diſtance) ſet one Foot in B, and with the other croſs the former Arch (both above and below the Line) in the Points F and G: So a Right Line drawn (or a Ruler laid) from F to G, ſhall cut the given Line in H; ſo ſhall the given Line A B be divided into two Equal Parts in the Point H, and at right Angles, which was required.

## PROBL. V.

*A* Right Line *being given, to draw another* Right Line *which ſhall be* Parallel *thereunto at any diſtance required, or through any Point aſſigned.*

*Definition.*] R*ight Lined Parallels* are ſuch Right Lines, which being drawn upon the ſame Plain, and infinitely extended on either ſide, would never concur or meet; but always, in all parts, retain

retain an equal diſtance; and ſuch are theſe two Right Lines, B C, and B D.




In the deſcribing or drawing of *Parallel Lines*, there may fall out *Two Caſes*, or *Varieties*. As,

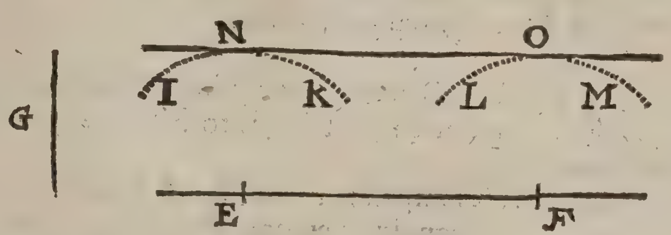
1. It may be required to draw a Line *Parallel* to another Line, at a certain given diſtance. Or,

2. The *Parallel* may be required to be drawn through an aſſigned *Point*.

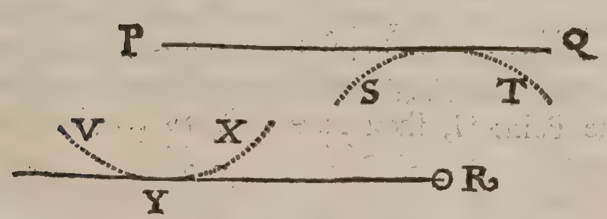
And of this kind there are two *Varieties*. For,

1. The given *Point* may be *over* or *under* the given Line. Or,

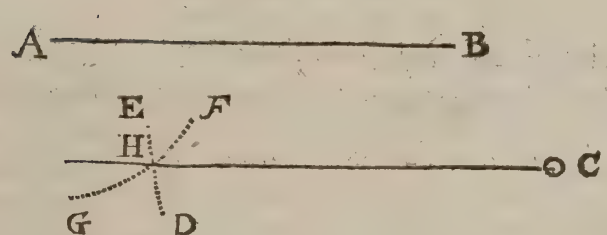
2. It may be *Oblique* to the Line given.




1 *Caſe.*




2 *Caſe.*




3 *Caſe.*

*Practice of the First Caſe.*

LET E F be a Right Line given, and let it be required to draw another Right Line Parallel thereunto at the diſtance of the Length of the Line G.

Firſt, Take in your Compaſſes the Length of the given Line G, and ſet one Foot in the Point E, (or in any other part of the given Line towards the end thereof) deſcribing the ſmall obſcure Arch I K.——Then move the Compaſſes to F, (near the other end of the Line) and deſcribe another ſmall and obſcure Arch L M. ——Laſtly, Lay a Ruler to the very top of theſe two *Arches*, ſo that the Ruler do not croſs, but juſtly *touch* either of them: Then if by the edge of the Ruler you draw a Right Line N O, it ſhall be Parallel to the given Line E F, and at the diſtance of the Length of G; which was to be done.

Pra-

*Practice of the Second Case.* LET PQ be a Right Line given, unto which you are to draw another Right Line Parallel, which *Parallel* must pass through the given Point R.

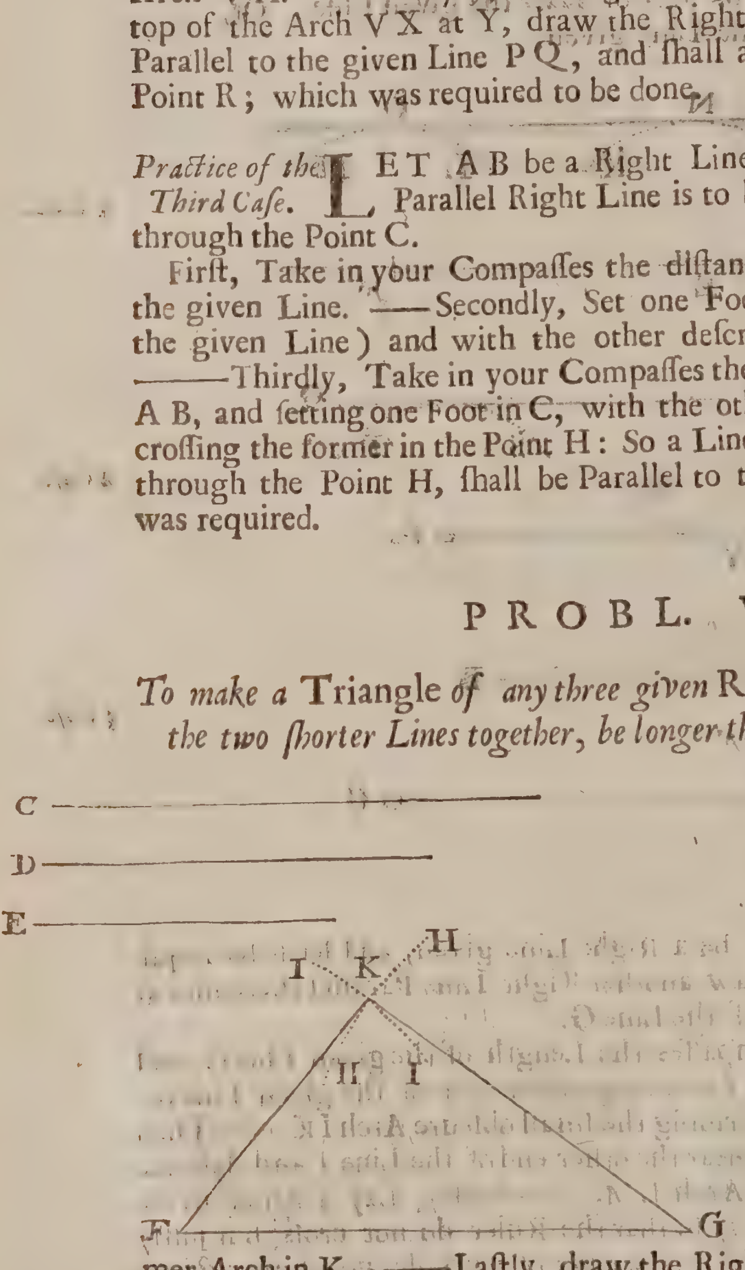
*First*, Set one Foot of your Compasses in R, and with the other take the nearest distance to the given Line P Q, which is done by opening or shutting of the Compasses, till the moveable Point of them do only touch the given Line P Q, and there describe the Arch S T.—— *Secondly*, The Compasses at the same distance, set one Foot in P, (or any Point towards the other end of the given Line) and with the other describe the Arch V X. ——— *Lastly*, Through the given Point R, and the very top of the Arch V X at Y, draw the Right Line R Y, and it shall be Parallel to the given Line P Q, and shall also pass through the given Point R; which was required to be done.

*Practice of the Third Case.* LET A B be a Right Line given, to which another Parallel Right Line is to be drawn, which shall pass through the Point C.

First, Take in your Compasses the distance from C to B, the end of the given Line. ——Secondly, Set one Foot in A (the other end of the given Line) and with the other describe the obscure Arch F G. ———Thirdly, Take in your Compasses the Length of the given Line A B, and setting one Foot in C, with the other describe the Arch D E, crossing the former in the Point H: So a Line drawn from the Point C, through the Point H, shall be Parallel to the given Line A B; which was required.

## PROBL. VI.

*To make a* Triangle *of any three given* Right Lines, *provided that the two shorter Lines together, be longer than the longest given Line.*

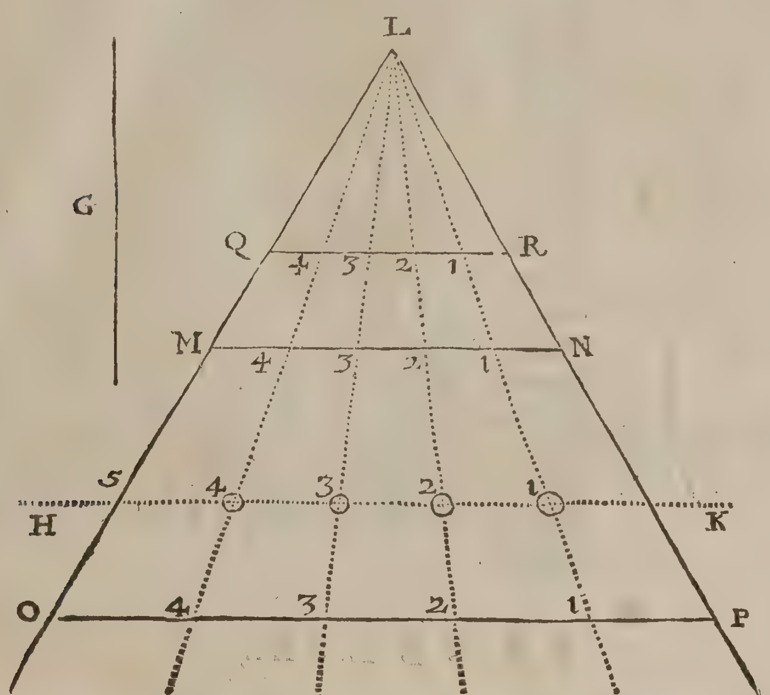



LET the three Lines given be C, D, and E. ——First, Take the longest Line C in your Compasses, and make the Line F G equal thereunto. Secondly, Take in your Compasses the Line D, and setting one Foot in G, describe the Arch H H. ———Thirdly, Take the Line E, and setting one Foot in F, describe the Arch I I, crossing the former Arch in K. ——Lastly, draw the Right Lines K F and K G, and they shall constitute a Triangle, whose three sides shall be equal to the three given Lines, C, D, E; which was required.

PROBL.

## PROBL. VII.

*To divide a Right Line given, into any number of* Equal Parts.



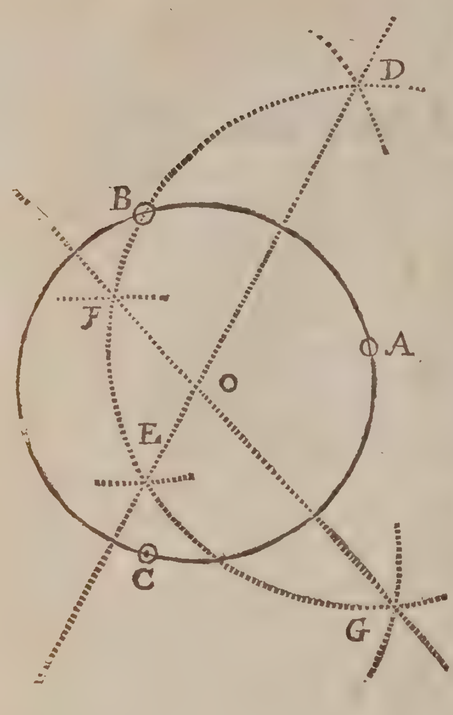

*Practice.*] LET the Right Line G be the Line given, to be divided into 5 equal parts. First, Upon any Line drawn at pleasure, as the obscure Line H K, with your Compasses opened to any small distance, run along the same Five times at the figures o, 1, 2, 3, 4, 5. (because the Line given is to be divided into 5 parts). ——Then take in your Compasses the distance from o to 5, and with that distance make the *Equilateral Triangle* 5 L o. ——Again, Take in your Compasses the given Line G, and set that distance from L to M and N, drawing the Line M N (which will be equal to the given Line G.) ——Lastly, Lay a Ruler from L, to the Points 1, 2, 3, and 4, in the Line H K, and the Ruler will cut the Line M N in the Points 1, 2, 3, 4; dividing the same Line, equal to G, into 5 equal parts; as was required.

¶ *Note*, This *Equilateral Triangle* thus made, is capable of dividing any other Line into 5 equal parts, be it either greater or lesser than this given Line G, if the length thereof be set from L on both sides of the Triangle, and drawing a Line from either side: As the Line Q R shorter than M N; or the Line O P longer than M N: All which Lines are divided into Five Equal Parts.

## PROBL. VIII.

*To any three* Points *given, which lye not in a Right* Line, *to find the* Center *of a* Circle, *whose* Circumference *being described, shall pass through those three given* Points.

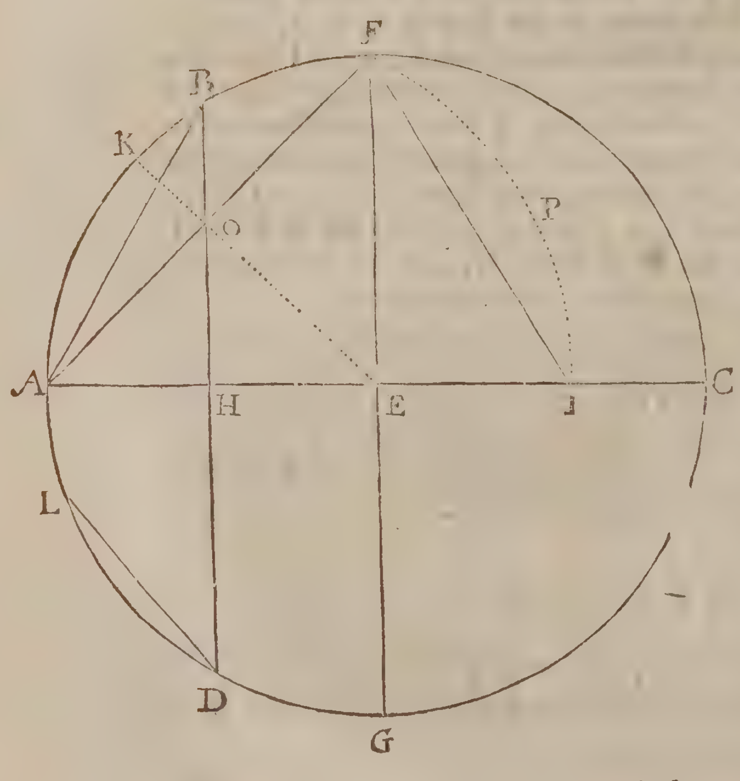
Let




LET the three given Points be A B C. *First*, Set one Foot of your Compaffes in one of the given Points A, and extend the other Foot to B, another of the given Points, and draw the Arch of a Circle G E D. ——*Secondly*, (the Compaffes being kept at the fame diftance as before) Set one Foot in B, and with the other Foot crofs the former Arch G E D, with two fmall Marks or Arches in the Points D and E, and draw the Right Line D E. ——*Thirdly*, Set one Foot of the Compaffes in the third given Point C, (they ftill keeping the fame opening) and with the other Foot crofs the firft drawn Arch G E D, in the Points F and G, and draw the Right Line F G, croffing the former Right Line D E in the Point O, fo fhall O be the Centre of a Circle; in which if you fet one Foot of the Compaffes, and open the other to any of the three given Points, the Circle fo defcribed fhall pafs directly through all the 3 Points A B and C, as was required.

## PROBL. IX.

*To divide the Circumference of any Circle into any number of equal Parts, not exceeding Ten.*



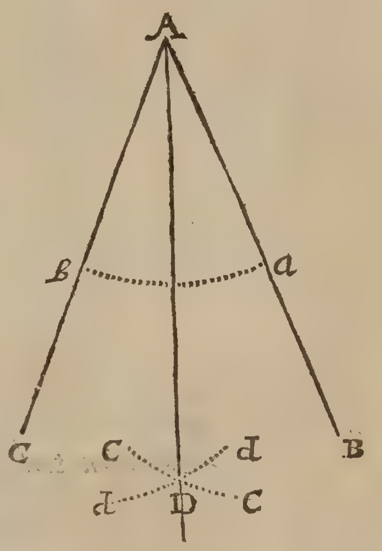

THE Circle being defcribed upon the Centre E, ——*Firft*, Draw the Diameter A E C, which divides the Circumference into 2 equal parts. ——*Secondly*, Take the diftance A E in your Compaffes, and fet it from A to B, and to D, and draw the Line B D, which fhall divide the Circumference into 3 equal parts. ——*Thirdly*, Divide the Diameter A C in two equal parts at right Angles, by the Diameter F G, and draw the Line A F, which fhall divide the Circle into 4 equal parts. ——*Fourthly*, Set one Foot of the Compaffes in H, and extend the other to F, and there defcribe the Arch F P I, and draw the Line F I, which fhall divide

vide the Circle into 5 equal parts.—— *Fifthly*, The lines E A, E C, E F, or E G, will either of them divide the Circle into 6 equal parts. ---*Sixthly*, The lines H B or H D will divide it into 7 equal parts.—— *Seventhly*, Through the point O, ( where the lines H B and A F do interſect ) draw the line E K, and a line drawn from A to K ſhall divide the Circle into 8 equal parts. —— *Eighthly*, Divide the Arch B A D into three equal parts, and ſet one of them from D to L, ſo ſhall D L divide the Circumference into 9 equal parts.——*Laſtly*, The Line E I will divide the Circle into 10 equal parts; and ſo is the Problem performed as was required.

## PROBL. X.

*To divide a Right Lined Angle into two equal Parts.*

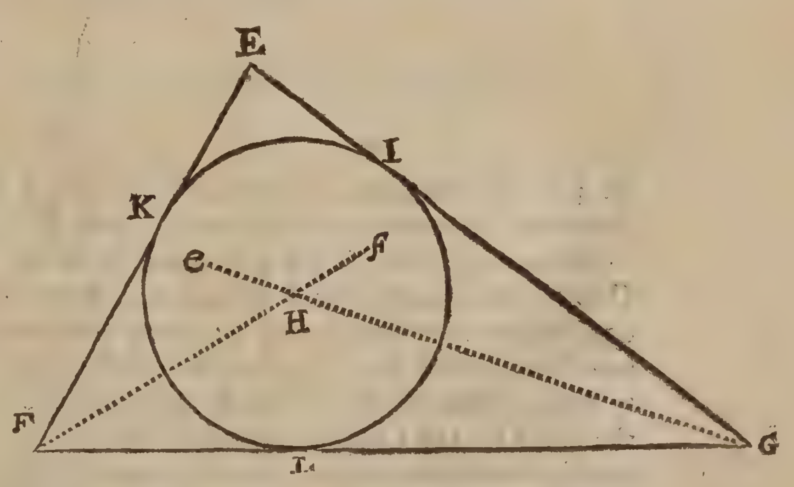
LET the Angle given be C A B; upon the Angular Point at A, with any diſtance of the Compaſſes, deſcribe an Arch a b, then ſet one foot in a, and with the other deſcribe the Arch c c; and ſet one foot in b, and with the other deſcribe the Arch d d, croſſing the former in the point D, through which draw the Line D A, ſo ſhall the Angle C A B be divided into two equal parts by the Line D A.




## PROBL. XI.

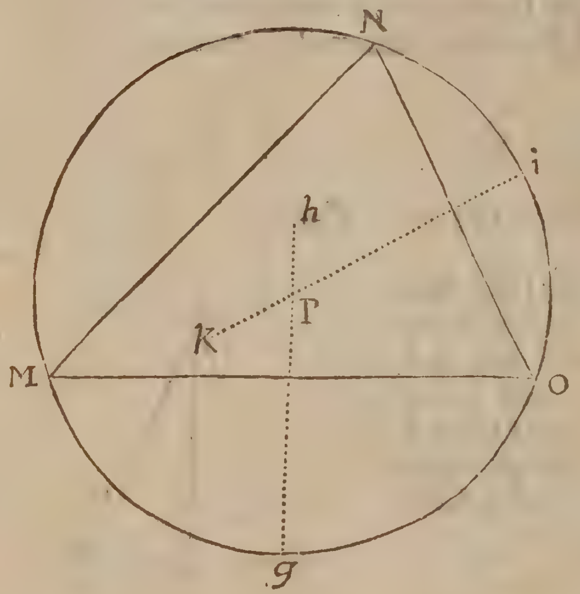
*How to deſcribe a Circle within a Triangle, ſo that the Circumference of the Circle ſhall touch all the three ſides of the Triangle.*

BY the laſt Problem divide any two of the Angles of the given Triangle into two equal parts, as the Angles E F G, by the line F f, and the Angle E G F by the line G e, cutting each other in H; ſo is H the Center, upon which if you deſcribe the Circle, it ſhall touch the three ſides of the Triangle in the Points I K and L.



## PROBL. XII.

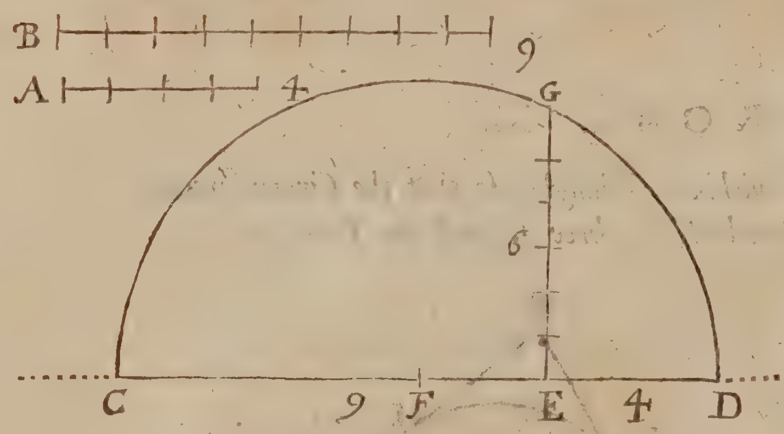
*To describe a Circle about a Triangle, the Circumference whereof shall touch all the Angles of the Triangle.*




LET the Triangle given be M N O, by the fourth Problem divide any of the two sides of the Triangles into two equal parts, at Right Angles, as the side M O, by the line g h, and the side N O, by the line i k, crossing each other in P; so is P a Center, upon which if you describe a Circle, it shall touch all the Angles of the Triangle.

## PROBL. XIII.

*Between two Right Lines given, to find a Mean Proportional Line.*




*Definition.* A *Mean Proportional* Line, is such a Line, whose length being multiplied in it self, the Product shall be equal to both the Product of the other two Lines, between which it is a *Mean Proportional.*

Let A and B be two lines, of which let A be 4 of any Measure, (as Feet, Yards, *&c.*) and let B be 9 of the same measure; and between these two I would find a Mean Proportional.

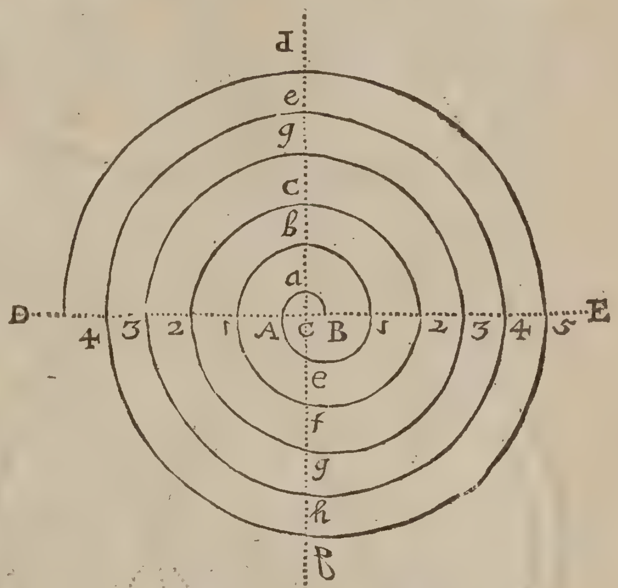
Draw a right line C D, and upon it set the line B, which is 9, from C to E; also set the line A, which is 4, from E to D; so is the line C D, equal to the two lines A and B; upon the point of the joining of these two lines, which is at E, (by the first Problem) erect a Perpendicular, as E G; then divide the line C D into two equal parts in F, and upon the point F, as a Center, describe a Semicircle C G D, cutting the Perpendicular before erected, in the point G; then is the line E G a Mean Proportional Line between the two lines A and B, and being measured, will

will be found to be 6; which being multiplied in it ſelf produceth 36; and ſo will 9 multiplied by 4 produce the ſame.

## PROBL. XIV.

*How to make a Serpentine or Spiral Line, whoſe thrids ſhall be diſtant one from the other, the length of a Line given.*

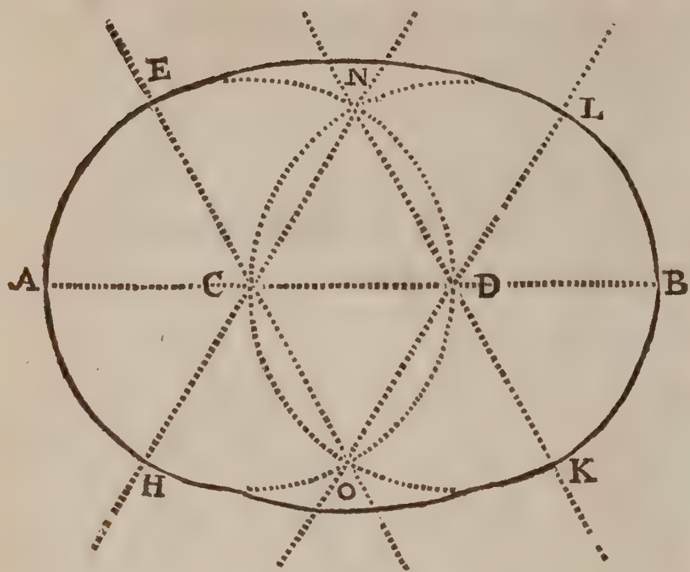
LET it be required to deſcribe a Spiral Line, at the diſtance of the given Line A B. ——— Continue the given line A B at pleaſure on both ſides, from A towards D, and from B towards E; and upon this continued Line (with the diſtance A B) ſet off the diſtances 1, 2, 3, &c. on either ſide from A and B. Then (by Probl. 1.) divide the given line A B into two equal parts in the point C, and upon C, as a Centre, at the diſtance C A or C B, deſcribe the Semicircle A a B: Then opening the Compaſſes from C to 1, upon C deſcribe the Semicircle 1 b 1; alſo extend the Compaſſes from C to 2, and upon C deſcribe the Semicircle 2 c 2. Again, Open the Compaſſes from C to 3, and deſcribe the Semicircle 3 d 3: And thus may you do for as many Revolutions as you pleaſe, as here is done only for three.

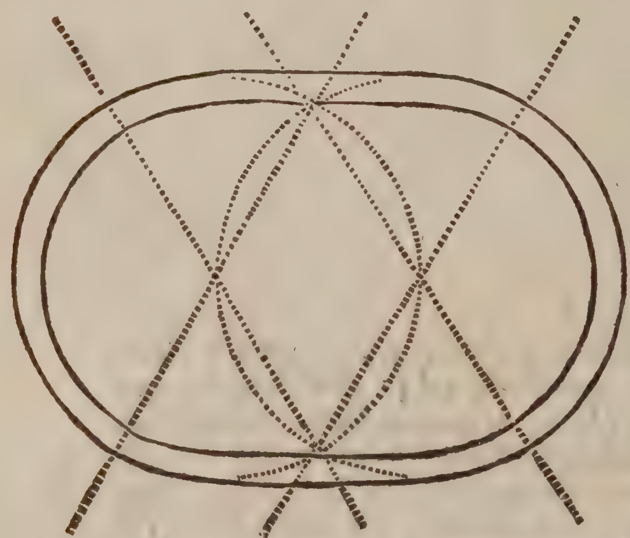



Again, Open the Compaſſes to the diſtance of the given line A B, ſet one foot in B, and with the other deſcribe the Semicircle A e 1. Then extend the Compaſſes from B to 1, and deſcribe the Semicircle 1 f 2. Laſtly, Extend the Compaſſes from B to 2, and deſcribe the Semicircle 2 g 3. So is your Spiral Line finiſhed, conſiſting of Three Revolutions only, but may be continued to as many as you pleaſe.

## PROBL. XV.

*How to deſcribe an Oval, the length thereof being given.*



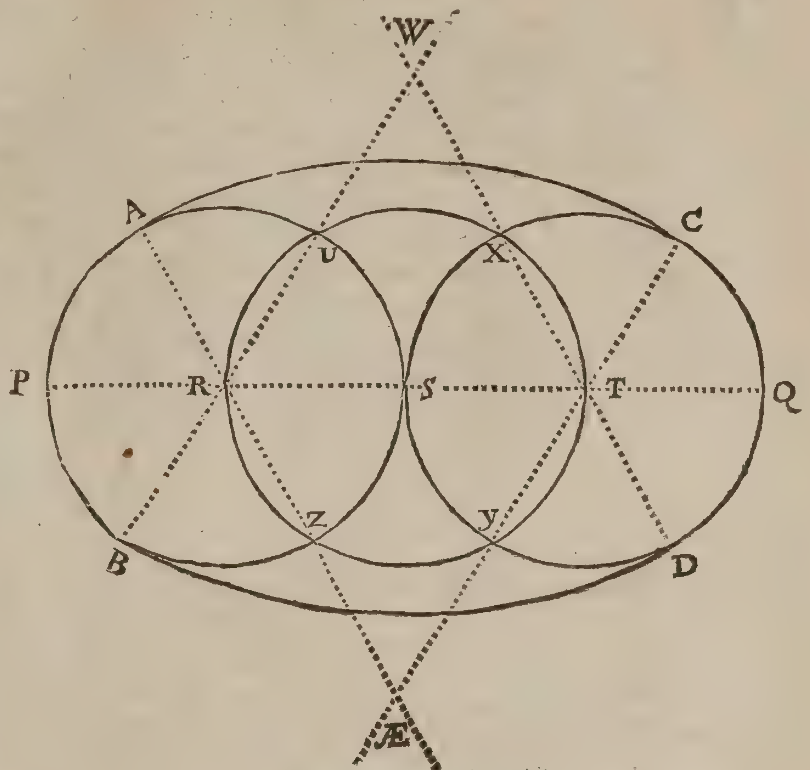
LET A B be a line given, and of that length let it be required to deſcribe an Oval. —— Divide the line A B into three equal parts in the Points C and D. Then upon C as a Centre, at the diſtance C A, deſcribe the obſcure Circle E A H D; and upon D, at the diſtance D B, deſcribe another occult Circle L B K C, croſſing the former in the points N and O. This done, through O and C draw an obſcure line cutting the Circle in E: Alſo through O and D, draw another obſcure line, croſſing the other Circle in L. In like manner, through the points N and C, draw an obſcure line cutting the Circle in H, and through N and D another cutting the Circle in K. Laſtly, Upon O, at the diſtance O E or O L, deſcribe the Arch E L, and (with the ſame diſtance) upon N, deſcribe the Arch H K. The two ends of the Oval H A E, and L B K are parts of the two Circles firſt of all deſcribed; and ſo is your Oval compleated.

*If you would draw an Oval Parallel to an Oval, you muſt deſcribe it upon the ſame Centres, and to touch the lines* O E, O L, *and* N H, N K, *extended as is done in the Figure.*

## PROBL. XVI.

*At the length of a line given, to deſcribe an Oval, which ſhall be in proportion to the length thereof, narrower than the former.*

LET

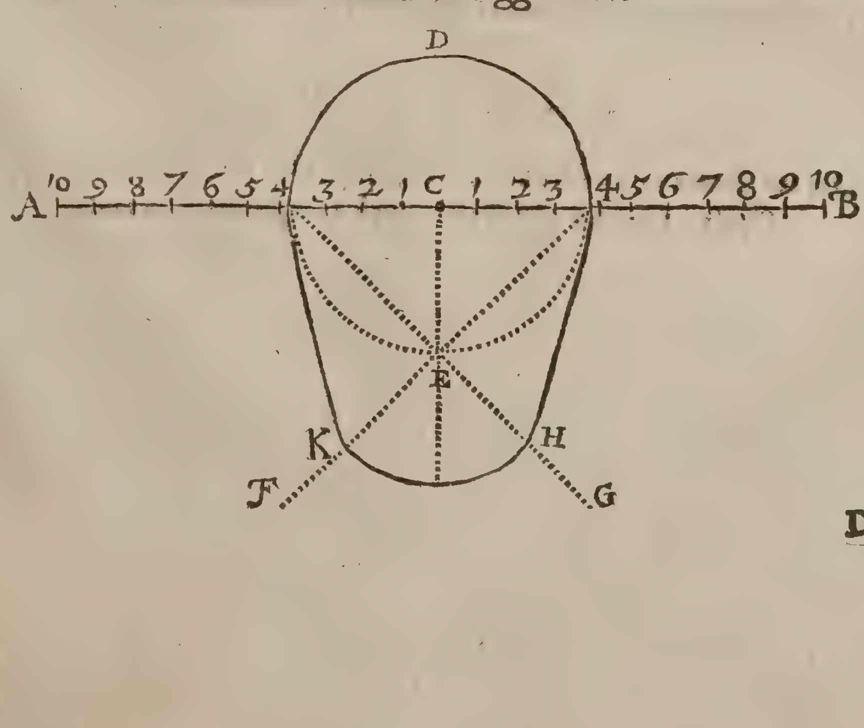



LET the given line be P Q —— Divide the line P Q (by the 13*th.* Probl.) into four equal parts in the points R S and T, and upon those three points, as three Centers, at the distance R P, or T Q, describe three Circles, the middlemost of which, described upon the Center S, cutting the other two in the points U X Y Z. This done, through the points R Z draw an obscure line at length, and cutting one of the Circles in A; also draw a line through T and Y, crossing the other Circle in C, and the line A Z extended to Æ. ——Again, through T and X draw an obscure line at liberty, cutting one of the Circles in D, and another obscure line through R and V, cutting the other Circle in B, and being extended through the former occult line in W. Lastly, Upon the Point Æ, at the distance Æ A, describe the Arch A C, and (with the same distance) one foot placed in W, with the other describe the Arch B D, compleating the Oval; the ends A P B, and C Q D, being parts of the two outermost Circles first described.

*If you would have an Oval Parallel to this, it must be described upon the same Centres* R T W *and* Æ.

## PROBL. XVII.

### *How to make an Egg Form.*

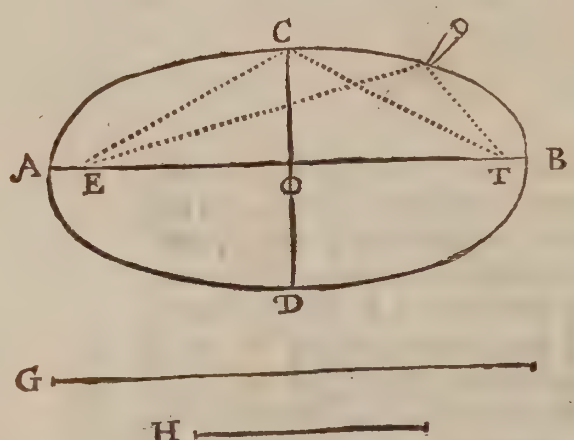



Draw

DRaw a right line A B, which divide into two equal parts in C. Then divide each of thoſe parts C B and C A into 10 equal parts, and number them from C both ways, by 1, 2, 3, &c. to 10. —— Then take in your Compaſſes 4 of thoſe parts, and with that diſtance, upon C, deſcribe the Circle D 4 E 4, and draw the two lines 4 E F, and 4 E G, extending them of ſufficient length. —— Then ſetting one foot of the Compaſſes in B, extend the other to the 4 next to A (or take 14 parts in your Compaſſes) and ſetting one foot in A deſcribe an Arch till it cut the line E G in H, and with the ſame diſtance, ſetting one foot in B, deſcribe an Arch, cutting the line E F in K. ——Laſtly, Set one foot in E, and with the other, opened to the diſtance E K or E H, deſcribe the Arch K L H; and ſo is your Egg figure compleated.

## PROBL. XVIII.

*How to deſcribe an Oval (properly an Ellipſis) whoſe length and breadth is given.*

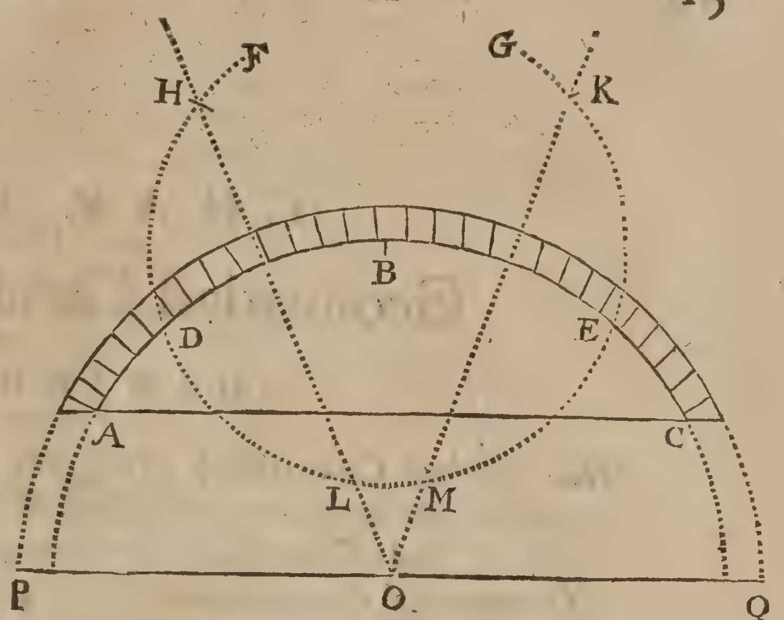



LET G and H be two lines given, and an Oval (or Ellipſis) is to be deſcribed, whoſe length is to be equal to the line G, and its breadth to the line H. ——Draw a line A B equal to the line G, and (by Probl. 1.) divide it into two equal parts at Right Angles in the point O, and make the line C D equal to the given line H. This done, take in your Compaſſes the length O A or O B, (half the length of the longeſt Diameter) and ſetting one foot in C, with the other croſs the Diameter A B, in the points E and F; which two points are the two Centers of the Oval, (properly the two Focus of the Ellipſis): Upon which two points, let two Pins be faſtned, and about them put a String, whoſe ends faſten together in the point C; this ſtring being moved about the two Pins with a Point or Tracer, will deſcribe the Oval (or Ellipſis) A C B D, whoſe length and breadth ſhall be equal to the two lines G and H.

## PROBL. XIX.

*To find the Center of a Circular Arch, and the whole Diameter of the Circle, of which the given Arch is a part or Segment.*

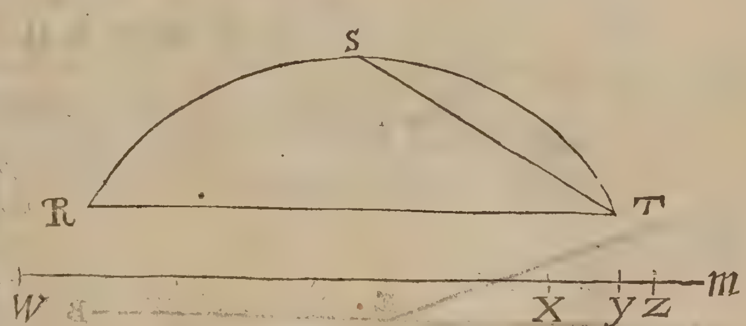
LET




LET A B C be the inside of a Circular Arch, of which the whole Diameter and the Center is required to be found.——Make choice of a Point towards the Top or Crown of the Arch, as B, in which set one foot of the Compasses, opening them to any competent distance, as from B to D or E, and with that distance describe an obscure Circle F D E G, crossing the Arch in D and E. Then (the Compasses being still open to the same distance) set one foot in D, and with the other make the marks F and L in the obscure Circle: Also set one foot in E, and with the other make the marks K and M in the same obscure Circle. This done, draw an occult line at pleasure, through the points H and L, and another through M and K, crossing the former in the point O: So shall O be the Center of the Arch, and O A, O B, or O C, the Semidiameter of the Circle of which the Arch is a part. The whole Diameter may be found by continuing the sides of the Arch from the Springs A and B, downwards towards P and Q; Then a line drawn through the Center O, parallel to A B, till it meet with the Arch continued on both sides at P and Q, shall be the Diameter of the Arch.

## PROBL. XX.

*The Arch or Segment of a Circle being given, to find a Right Line (the nearest) equal thereunto.*




THE Arch R S T is a Segment of a Circle, unto which a Right line is to be made equal. —From the two extream points of the Arch, draw a right line R T; then divide the Arch line into two equal parts in S, and draw the right line S T. This done, draw a right line at pleasure, as W m; upon which line set the length of the line R T, from W to X: Also take the line T S in your Compasses, which at twice will reach from W to Y; divide the line of difference X Y into 3 equal parts, and one of those parts set from Y to Z; so shall the right line W Z, be the nearest right line that can Geometrically be found, equal to the Arch Line or Segment R S T.

CHAP.

# CHAP. II.

# Geometrical Concluſions.

## SHEWING

*How ( without* Compaſſes ) *having only a common* Meat-Fork, *( or ſuch like Inſtrument, which will neither open wider, nor ſhut cloſer ), and a Plain Ruler, to perform many pleaſant and delightful* Geometrical Concluſions.

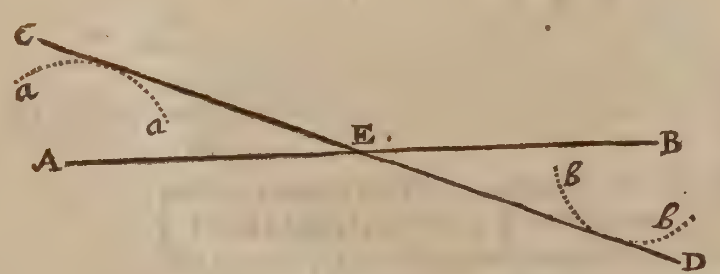
THE *Compaſſes* is an Inſtrument known to all men; and the Invention of them is attributed to *Talus* the Nephew of *Dædalus*; as appears by *Ovid Met. Lib.* 8. Where he ſays,

*—— Et ex uno duo ferrea brachia nodo*
*Junxit, ut equali ſpacio diſtantibus illis*
*Altera pars ſtaret, pars altera duceret orbem.*
Which *Sandys* thus Tranſlates,
And two ſhankt *Compaſſes*, with Rivet bound,
Th'one to ſtand ſtill, th'other to turn round
In equal diſtance.

But one *John Baptiſt* an *Italian*, as alſo one *Jeronymus Cardanus*, a famous Mathematician, have performed and demonſtrated all ( as is related ) *Euclid*'s Elements, without Compaſſes; it is true, many Concluſions may be done without them, ſome whereof ſhall here follow:

### CONCLUS. I.

*How to divide a Right Line into two equal Parts.*




LET A B be a right line given to be divided into two equal parts; ſet one point of the Fork in A, and with the other draw the ſmall Arch a a; then ſet one end of the Fork in B, and with the other deſcribe the Arch b b; then lay a Ruler to theſe two Arches a a and b b, ſo that the Ruler may only touch the tops of the Arches; then by the ſide of the Ruler draw the line C D, which will divide the given line A B into two equal parts in the point E; which was to be done.

CON-

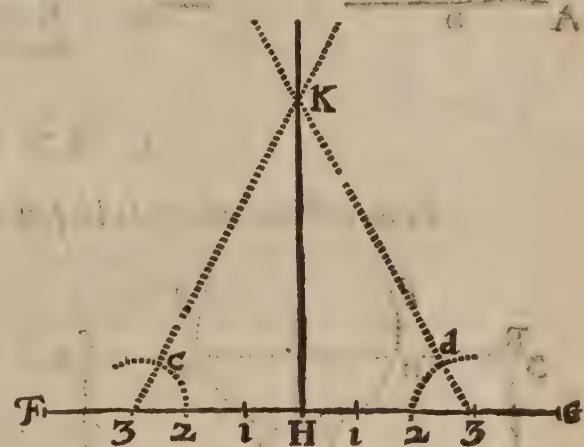
## CONCLUS. II.

*How to erect a Perpendicular from a Point given in any Right line.*

THis may be done ſeveral ways; as followeth:

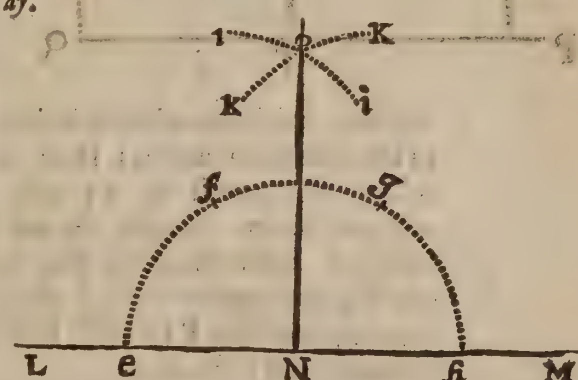
*The Firſt Way.*

Let F G be a right line, and H a point given therein, from whence it is required to erect a Perpendicular: Set one point of the fork in the given point H, and run it over upon the given line two, three, or four times, on either ſide of the given point H, at the Points 3 2 1, and 1 2 3; then upon the points 3 and 3, deſcribe the two Arches 3 c, and 3 d, ſetting the diſtance of the fork upon both the Arches from 2 to c, and from 2 to d: Then through the points 3 and c, and 3 and d, draw the two right lines 3 c, and 3 d, cutting one another in the point K; ſo a right line being drawn from H to K, ſhall be Perpendicular to F G; which was required to be done.



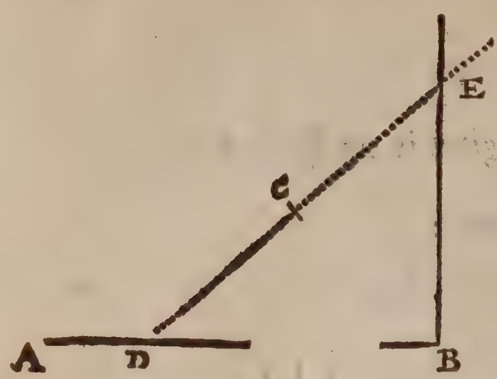

*Another Way.*

Let L M be a right line given, and N a point therein; from whence a Perpendicular is to be erected. Set one foot of the fork in the given point N, and with the other deſcribe the Semicircle e f g h; then ſetting one foot in e, the other will reach to f; and ſetting one foot in h, the other will reach to g; then ſetting one foot in f, with the other deſcribe the ſmall arch i i, and and ſetting one foot in g, with the other deſcribe the ſmall arch k k, croſſing the former arch in O, from the given point N draw the line N O, which ſhall be perpendicular to the line L M; which was to be done.




## CONCLUS. III.

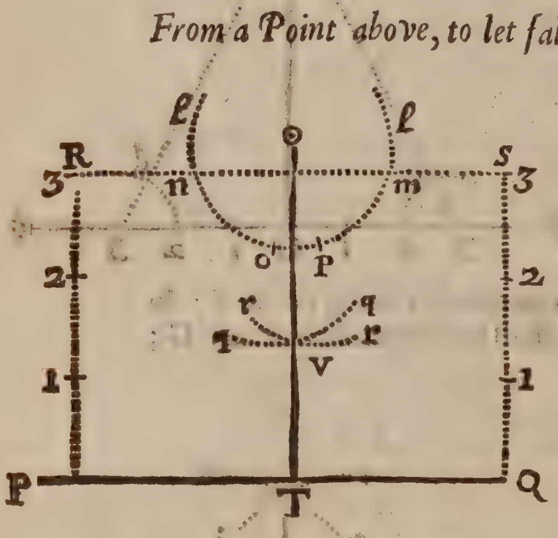
*Upon the End of a Right Line given, to Erect a Perpendicular.*



LET the given line be A B, and let it be required to erect a Perpendicular thereunto upon the end B. ——Set one point of your fork in the end B, and keeping it there, pitch the other down upon the Paper at all adventures in C, and upon C turn the fork about till the other point of it touch the given line A B in D; lay a Ruler from D to C, and draw an obscure line by the side thereof, and upon it set the distance of your fork from C to E; then a line drawn from B through E, shall be Perpendicular to the given line A B.

## CONCLUS. IV.

*From a Point above, to let fall a Perpendicular upon a ground line below.*



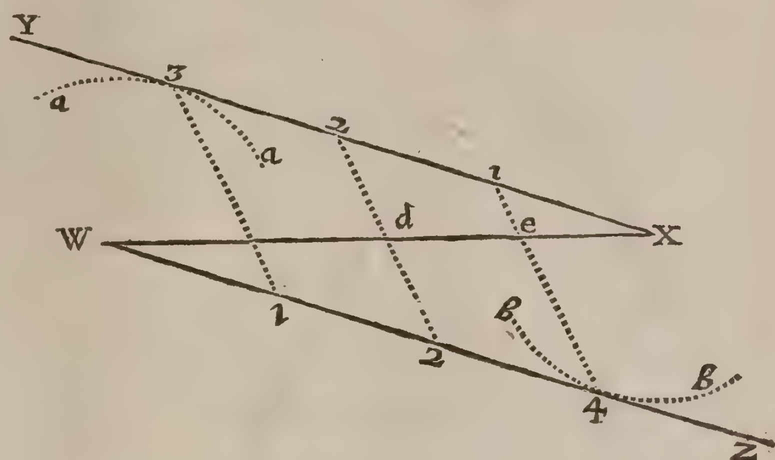
LET ⊙ be a point aloft, from which point it is required to draw a line which shall be Perpendicular to the right line P Q.

Upon the ends or towards the ends of the given line, erect two Perpendiculars as P R and Q S, upon which run over your fork as many times as you can, as at 1 1, 2 2, 3 3, *&c.* so far, till you come to have your given point to be nearer to the Parallel Line 3 3, than is the distance of your fork: Then set one foot of the fork in the given point ⊙, and with the other describe the Arch l l, cutting the Parallel 3 3, in the points m and n; then set one foot of the fork in m, and the other will reach to o; also set one foot in n, and the other will reach to p. Again, set one foot in o, and with the other describe the arch q q, and setting one foot in p, with the other describe the Arch r r, crossing each other in V. Lastly, draw the line ⊙ V, extending it till it cut the given line P Q in T; so shall ⊙ T be Perpendicular to P Q; which was required to be done.

## CONCLUS. V.

*To divide a Right Line into any number of equal parts.*

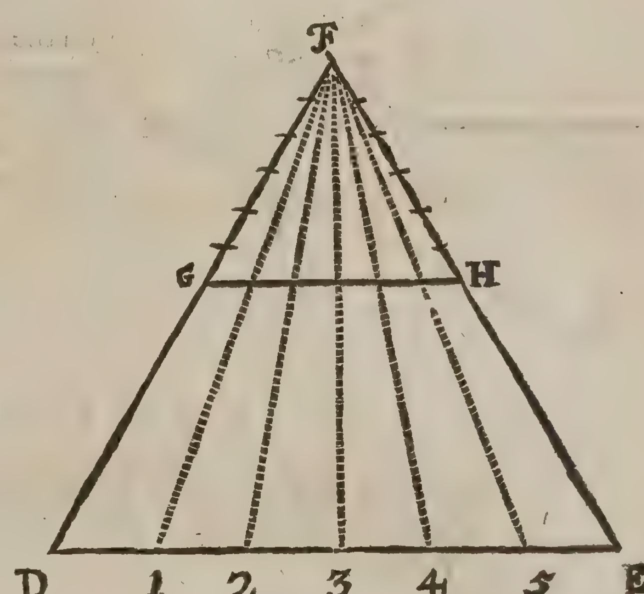
LET




LET W X be a right line given to be divided into 4 equal parts.

First, Upon the two points W and X, describe the two Arches a a above, the other b b below; then lay a Ruler to W, ſo as to touch the top of the Arch b b, and draw the line W Z, laying a Ruler to the top of the Arch a a, and the Point X, and draw the line X Y; then from W and X run the diſtance of your fork three times ( which is one leſs than the number of parts into which the line is to be divided ) at the points W 1, 2, and 3; and X 1, 2, and 3. Laſtly, draw the lines 1 3, 2 2, and 3 1; ſo ſhall the line W X be divided into four equal parts, in the points c, d, and e.

*Another Way to do the ſame.*

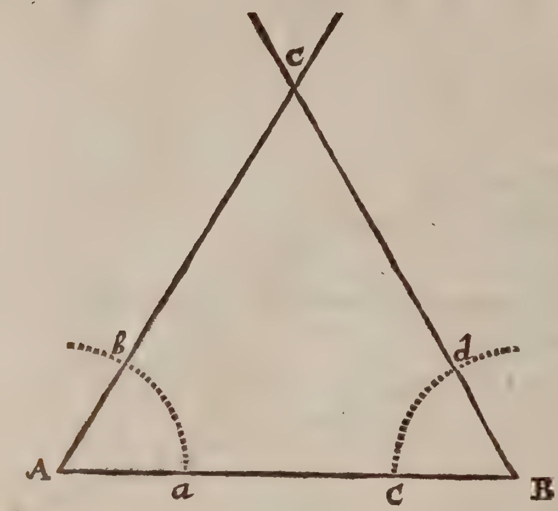



LET the given line be D E, and let it be required to divide the ſame into ſix equal parts.

First, By the following Concluſion, upon the given line D E, deſcribe the Equilateral Triangle D E F; then with the diſtance of your fork run ſix times upon the ſides F D and F E, at the points 1, 2, 3, 4, 5 G, and 1, 2, 3, 4, 5 H, and draw the line G H, upon which run alſo ſix times the diſtance of your fork, at the points a, b, c, d, e; then laying a Ruler upon F, and every one of the diviſions a, b, c, d, e, draw the obſcure lines F a, F b, F c, F d, F e, which extended, will divide the given line D E into ſix equal parts, in the points 1, 2, 3, 4, 5.

## CONCLUS. VI.

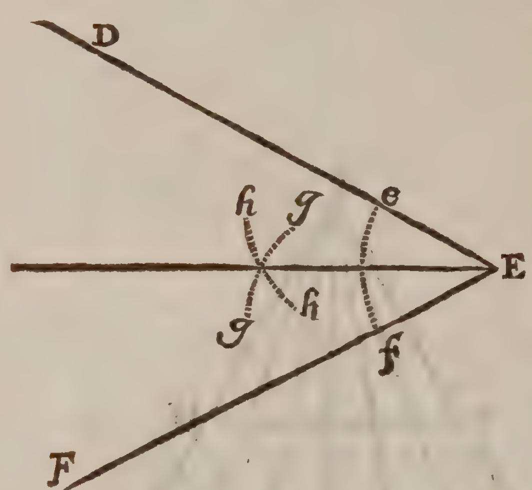
*Upon a Right Line given, to make an Equilateral Triangle, or a Triangle of three equal ſides.*




LET A B be the line given, upon the points A and B; with your fork deſcribe two Arches, and upon them ſet the diſtance of your fork from a to b, and from c to d; then draw the two lines A b and B d, extending them till they concur in C; ſo ſhall A B C be an equilateral Triangle, all whoſe ſides are equal to the given line A B.

## CONCLUS. VII.

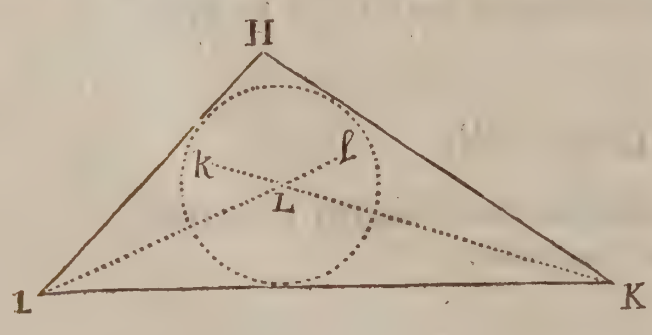
*To divide a Right Lined Angle into two equal parts.*




LET DEF be an Angle given, to be divided into two equal parts; upon the Angular Point E, with the diſtance of your fork, deſcribe the Arch e f; and upon the point f deſcribe the Arch g g, and upon e deſcribe the Arch h h, croſſing each other in G, draw the line E G, which ſhall divide the Angle D E F into two equal parts.

## CONCLUS. VIII.

*Within any Right Lined Triangle, to find a Point, upon which if a Circle be deſcribed, it ſhall juſtly touch all the three ſides of the Triangle.*




THE Triangle HIK is the Triangle given; by the foregoing Concluſion divide any two of the Angles into two equal parts, as the Angles I and K, by the Lines I l, and K k, croſſing each other in L, upon which a Circle being deſcribed, it ſhall touch all the ſides of the Triangle H I K.

CON-

## CONCLUS. IX.

*How to find a Point either within or without a Triangle, upon which, if a Circle be described, it shall touch all the Angular Points of the Triangle.*

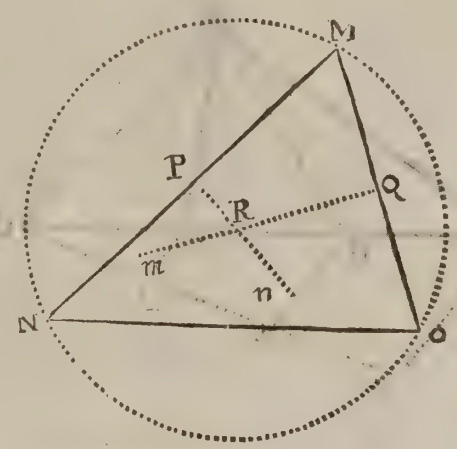



*Fig.* 1.

LET the Triangle given be M N O, and let it be required to find a Point, upon which a Circle being described, shall touch all the three Points M N and O.

By the second Conclusion divide any two of the sides of the Triangle, as the sides H O and M O, into two equal parts in the points P and Q; upon which points erect two Perpendiculars Q m and P n, crossing each other in R; so shall R be a Center, upon which a Circle being described, it will touch all the Angular Points of the Triangle M N O. In this case the Point R falls within the Triangle.

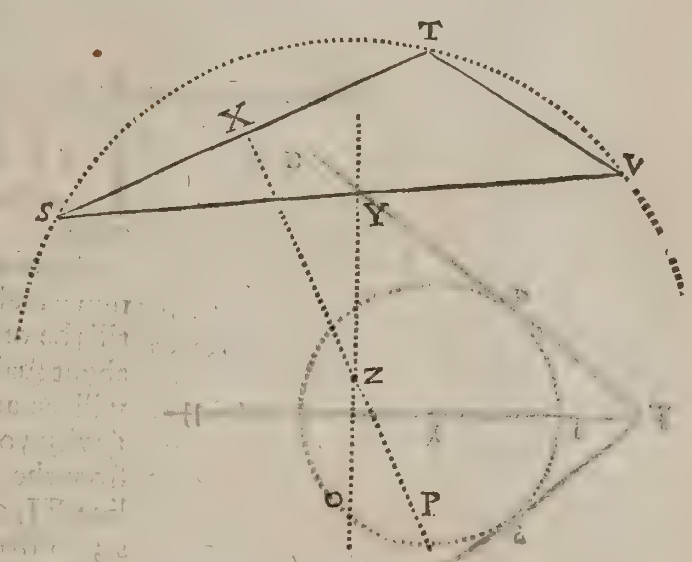



*Fig.* 2.

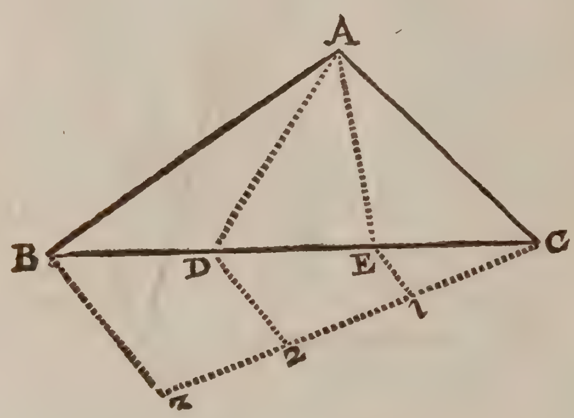
But if the Triangle had been that S T V, if the two sides thereof S T and S V had been divided into two equal parts of Right Angles, in X and Y, and from thence two Perpendiculars erected, as X p, and Y o, they would cross each other in the Point Z, without the Triangle, yet a Circle described upon that point, will pass by all the Angular Points of the Triangle.

*Note*, If the Triangle given be an Acute Angled Triangle, the Center will fall within the Triangle; as in the first example, *Fig.* 1.
But if it be an Obtuse Angled Triangle, the Center will fall without the Triangle; as in the second example, *Fig.* 2.
And if it be a Right Angled Triangle, the Center will fall in the middle of the longest side.

CON-

## CONCLUS. X.

*How to divide a Triangle into any number of equal Parts, by Lines drawn from any Angle thereof.*

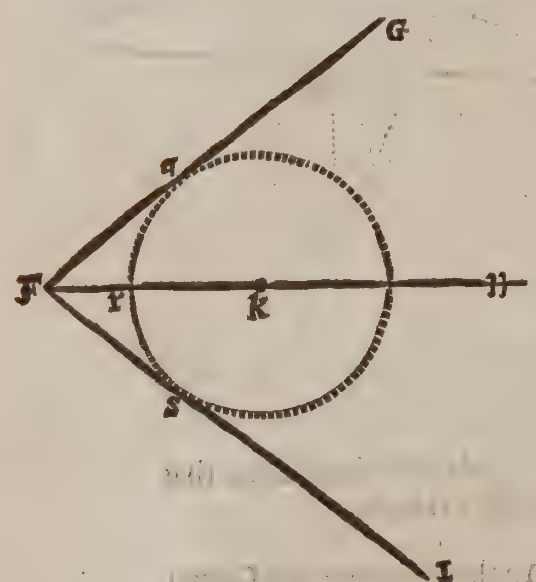


LET A B C be a Triangle given, to be divided into three Triangles by lines drawn from the Angle A.

Firſt, By the 4*th*. Concluſion divide the ſide of the Triangle B C (which is oppoſite to the Angle A, from which the lines of diviſion are to be drawn) into three equal parts in the points D and E; then draw the lines A E and A D, ſo ſhall you have three Triangles, A B D, A D E, and A E B, all of them equal one to another, and all of them together equal to the given Triangle A B C.

## CONCLUS. XI.

*How to make an Angle equal to an Angle given.*



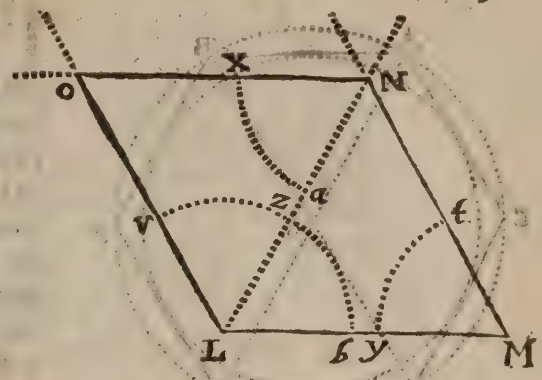
LET G F H be an Angle given, unto which it is required to make another equal.

Set one foot of your fork upon F, and move it along upon the line (or ſide) F H, till the other foot of the fork being turned about ſhall only touch the ſide F G, which will be at the point K: Upon K deſcribe (with your fork) the Circle p q r s, and from the Angular Point F draw the right line F I, ſo that it only touch the Circle in s; ſo ſhall the Angle H F I, be equal to the Angle G F H.

## CONCLUS. XII.

*Upon a line given, to make a Rombus, or Diamond-like Figure.*

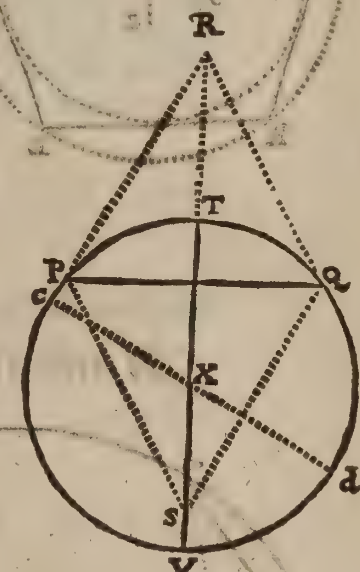
LET




LET L M be the line given; upon which, with your fork upon the end M, describe the Arch y t; also upon the end L describe the Arch b z v, and set the distance of your fork from y to t, from b to z, and from z to v; and draw the lines M t N, and L Z N, cutting each other in N; then upon N, with the distance of your fork, describe the Arch a x, setting the distance thereof from a to X, and draw the line N X at length: also from L draw the line L v, and extend it till it cuts the line N x, being extended in O: Lastly, draw the lines N O, and L O; so shall you have made a Rombus whose sides are all equal to the given line L M.

## CONCLUS. XIII.

*A Circle being given, to find the Center thereof.*



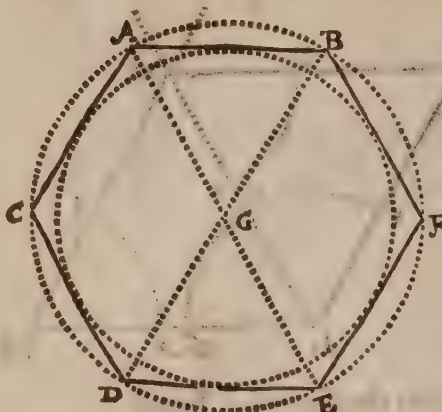

LET T P S Q be a Circle given, aud it is required to find the Center thereof.

First, draw a right line within the Circle, to cut the Circle in two points, as the line P Q; upon this line P Q (by the V*th.* Conclusion) describe two Equilateral Triangles, one above, as P R Q, and another below, as P S Q; through the points R and S draw the line R T S V; so shall T V be the Diameter of the Circle: Then with the distance of your fork set one foot in T, and with the other make the mark c, and setting one foot in S, make the mark d, (both in the Circumference of the Circle); then draw the line c d, cutting the diameter T S in X; so is X the Center of the Circle.

## CONCLUS. XIV.

*To find a Point within a Regular* Poligon, *of any number of equal sides and Angles, upon which Circles may be drawn; which Circles shall either circumscribe the Poligon, touching all the Angles thereof without, or be inscribed to touch all the sides within.*

IF

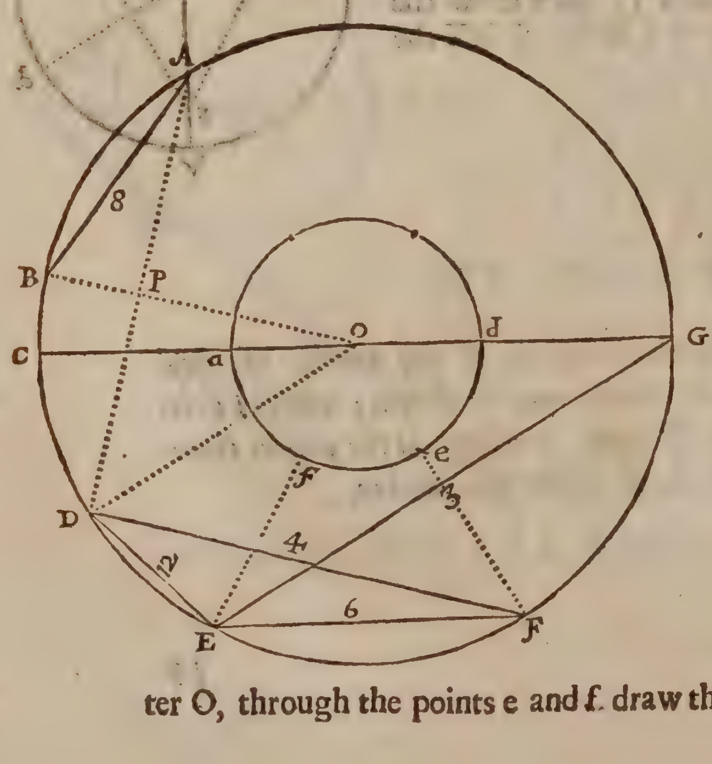



IF the *Poligon* be of an even number of sides, as 6, 8, 10, 12, *&c.* as the uppermost *Poligon* in the figure is of 6 sides; then you have no more to do, but to draw two lines from any two opposite sides, and their concurrence shall be the Center; as the lines A E and B D do intersect each other in the point G, which is the Center of *Poligon*, upon which a Circle may be drawn to circumscribe the *Poligon*, or one upon the same Center may be inscribed within the *Poligon*, only to touch the sides.


But if the *Poligon* consist of any odd number of sides, as of 5, 7, 9, *&c.* then (by the VI*th.* Conclusion) you must divide any two of the Angles thereof, into two equal parts, and the intersection of those lines of division shall give the Center either of the Inscribing or Circumscribing Circle about the *Poligon*; so in the lowermost *Poligon* of five sides the Angle I H M is divided into two equal parts by the line H e, and the Angle H M L is divided into two equal parts by the line M f, cutting the line H e in O; so is O the Center of the *Poligon*, upon which a Circle may be described, either to be circumscribed about, or inscribed within the regular *Poligon*.

## CONCLUS. XV.

*To divide a Circle into 2, 3, 4, 6, 8, and 12 parts, or more.*




THE Circle given is A B C D E F G H; then to divide it into two equal parts you have no more to do, but to draw a line through the Center thereof, as C O G; so is the Circle divided into two equal Parts or Semicircles, C B A H G, and C D E F G. But for the dividing it into the other parts,

First, With your fork (upon the Center O) describe a Circle, dividing it into Six equal parts (which the distance of your fork will do) in the points a b c d e f; then from the Center O, through the points e and f. draw the right lines O f E and O e F, between

between which draw the line E F ; which will divide the Circle into Six equal parts. Then (by the VIth. Conclusion) divide the Angle C O E into two equal parts, by the line O D, and draw the line D E, which ſhall divide the Circle into Twelve equal parts. Then draw a line from E to G, as E G, which ſhall divide the Circle into three equal parts. Then draw a line from D to F, which will divide the Circle into Four equal parts. Divide the line D A (which is equal to D F) into two equal parts in P, and draw the line O P, cutting the Circle in B ; ſo ſhall the line B A divide the Circle into Eight equal parts.

And after this manner may the Circle be divided into ſeveral other equal parts, but not into any number.

## CONCLUS. XVI.

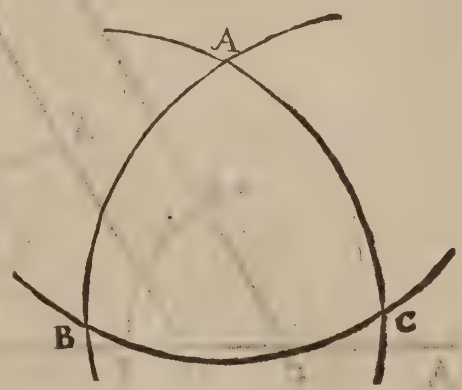
*How with your Fork to deſcribe a kind of Oval Figure, by once turning it about upon one Center.*

TAke a piece of Paper, and lay it upon a round Ruler, or Columb of Wood or Stone (if your fork be large), and the Paper lying ſtretched out upon the Columb, deſcribe thereon with your Fork a Circle, which when you have done, take the Paper from the Columb, and the Circle you there deſcribe, will now, the Paper lying flat, appear of an Oval Form.

## CONCLUS. XVII.

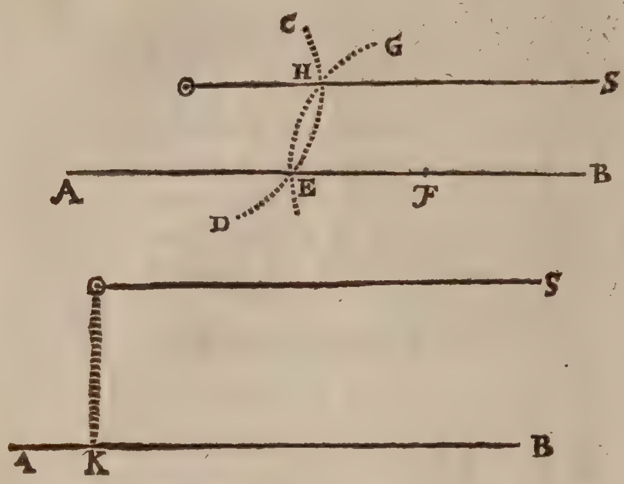
*How with your Fork to deſcribe a Spherical Triangle, which ſhall have three Right Angles, and all the ſides alſo equal one to the other.*

UPon a point A, with the diſtance of your fork, deſcribe an Arch B C ; then ſet one foot in B, in the former Arch, and with the other deſcribe the Arch A C ; and laſtly, ſet one foot in C, and with the other deſcribe the Arch B A, ſo ſhall you have deſcribed an Equilateral Equiangled Spherical Triangle A B C, whoſe Three Sides and Three Angles are all equal.




## CONCLUS. XVIII.

*Through a Point given, to draw a Line which ſhall be Parallel to a Line given.*



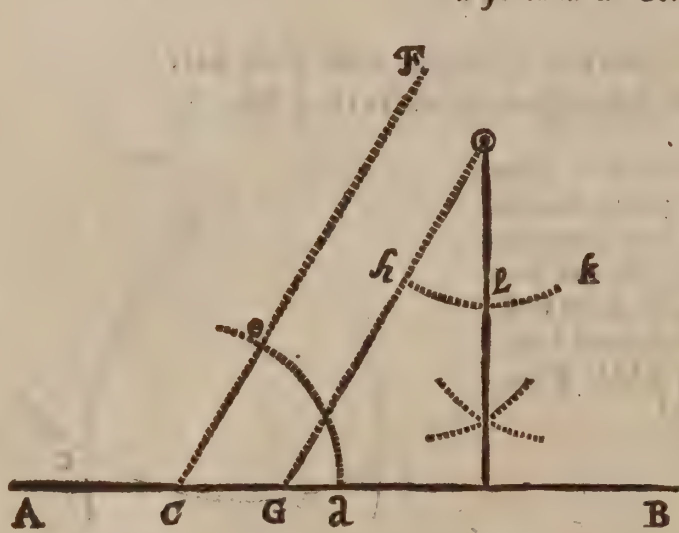

LET the Point given be ⊙, through which let it be required to draw a right line which shall be Parallel to the given line A B.

First, If the distance between the Point ⊙, and the given line A B, be less than the distance of your fork, then set one foot in ⊙, and with the other describe the Arch C D, cutting the Line A B in the point E: then set the distance of your fork from E to F, and upon F describe the Arch E G, cutting the former Arch D C in in H, a line drawn from ⊙ through H, (as ⊙ S) shall be Parallel to the line A B.

Secondly, But if the distance between ⊙ and A B be greater than the distance of your fork, then (by Concl. ) let fall a Perpendicular from ⊙ to A B (as ⊙ K) and upon the point ⊙ erect a Perpendicular (by Concl. ) to ⊙ K, as ⊙ S, so shall ⊙ S be Parallel to A B, as in the lowermost Scheme.

## CONCLUS. XIX.

*From a Point above to let fall a Perpendicular upon a line below, otherwise than in Conclusion* IV.



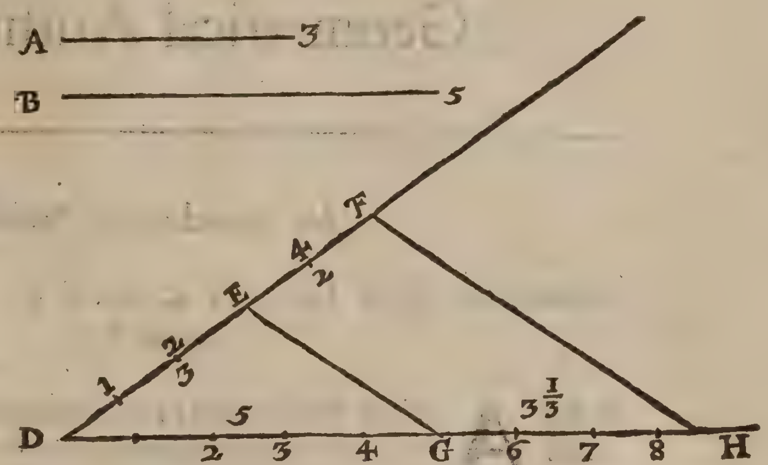

LET the given Point be ⊙, from whence a Perpendicular is to be let fall upon the Line A B.

Upon any part of the line A B, as C, with your fork describe an Arch, and upon it set the distance of your fork from d to e, and draw the line C F: Then (by the last Problem) through the point ⊙, draw a line Parallel to the line C F, as ⊙ G; then upon the point ⊙ with your fork describe an Arch, and set the distance of your fork upon it from h to k: Lastly, (by Conclusion VI.) divide the Angle h ⊙ k into two equal parts in l, and through l draw the right line ⊙ M, which shall be Perpendicular to the Line A B.

CON-

## CONCLUS. XX.

*Unto two given Right Lines, A 3, and B 5, to find a Third Line which shall be in proportion to them.*




THis is to perform the Rule of Three, or Golden Rule in Lines, (of which more hereafter in this Book). As if the Question were thus stated;

If 3 Yards of Cloath cost 5 Shillings;

What shall 5 Yards cost?

To perform this by this Artifice, draw two lines at length, making any Angle, as the lines D F and D H, making the Angle F D H: This done, with the distance of your fork, run three distances from D to E, upon the line D F, and 5 distances from D to G, upon the line D H, and draw the line E G; then run 5 distances (also) upon the line D F from D to F, and through F (by Conclusion XIX.) draw the line F H Parallel to E G, cutting the line D H in H; and then measuring with your fork from D to H, you shall find it to contain 8 distances of your fork, and one third part of a distance, which is 8 Shillings and 4 Pence, for the Price of Five Yards.

*Many more of the like Conclusions may be performed by this Artifice; but for the present let these suffice.*

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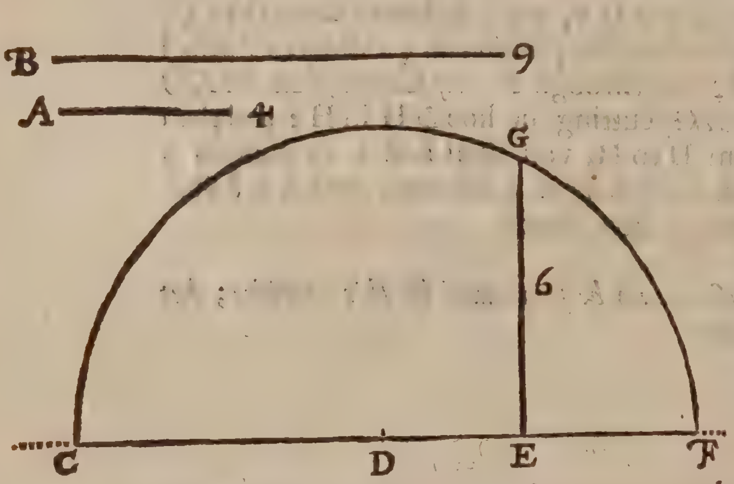
# CHAP. III.
# Geometrical Arithmetick.

## An Introductive Problem.

*Between two Right Lines, A 4, and B 9, to find a Mean Proportional Line.*

*Definition.* A *Mean Proportional Line between two other Lines, is ſuch a Line whoſe Length being multiplied in it ſelf, ſhall produce ſuch a Number as ſhall be equal to the Products of the lengths of the two given Lines, they being multiplied one by the other.*

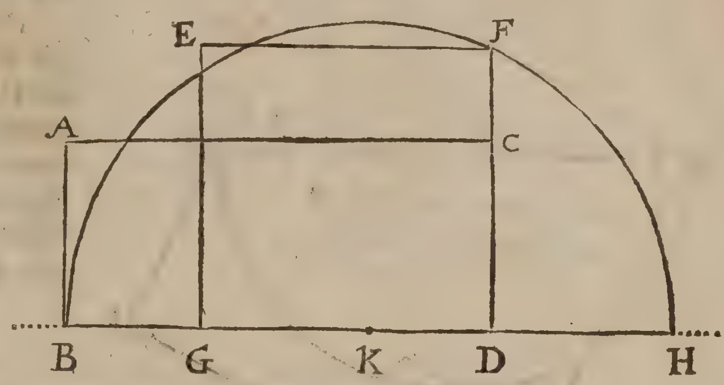



*Practice.* Draw a Right line at pleaſure, as the line C F, then take the length of the given line A 4 in your Compaſſes, and ſet it from F to E; alſo take the other given line B 9 in your Compaſſes, and ſet it from E to C; ſo is the line C F equal to both the given lines A 4 and B 9, (the point of joining them together being in the point E.) This done, divide the line C F into two equal parts in D, and upon D, as a Center, with the diſtance D C or D F, deſcribe the Semicircle C G F: Laſtly, from the point of joining of the two given lines A and B, namely, from the point E, erect the Perpendicular E G, cutting the Semicircle in G; ſo ſhall the line E G be a Mean Proportional between the two given Lines A and B, and will contain 6 ſuch parts, as the whole line C F contains 13, that is, as A 4, and B 9: And ſo this *Mean Proportional Line* E G, 6, multiplied in it ſelf will produce 36, equal to the line A 4, multiplied into the line B 9, for 9 times 4 is 36 alſo.

R E-

## REDUCTION.

I. *How to reduce a long Square or* Parallelogram A B C D, *into a Geometrical Square* E F G D, *whoſe four ſides are all equal.*



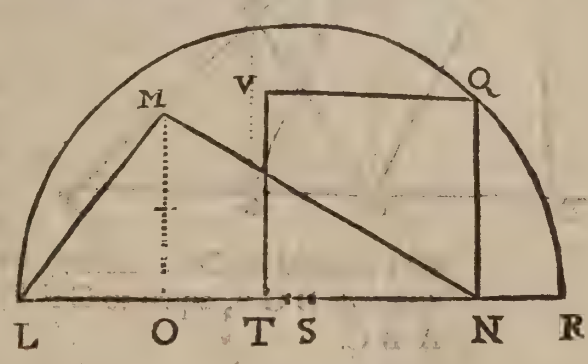

BY the Problem foregoing find a Mean Proportional Line between A B the ſhorter, and B D the longer ſide of the long Square A B C D, which will be found to be D F.

Firſt, Draw a line as B H, and upon it ſet one of the longeſt ſides of the Parallelogram, as A C, from B to D; alſo take the ſhorteſt ſide A B, and ſet that from D to H; and upon the point of joining at D, erect Perpendicular: Then divide the line B H into two equal parts in K, and upon K (as a Center) deſcribe the Semicircle B F H, cutting the Perpendicular D F in F; ſo ſhall D F be the ſide of the Geometrical Square, G E F D, which ſhall be equal in quantity to the long Square A B C D.

For,

Suppoſe the leſſer ſide of the Long Square A B to be 8 (of any meaſure) and the longer ſide A C to be 18, the Mean Proportional between them F D will be 12; and ſo 18 multiplied by 8, the Product will be 144; and ſo will 12 multiplied by 12, produce the ſame.

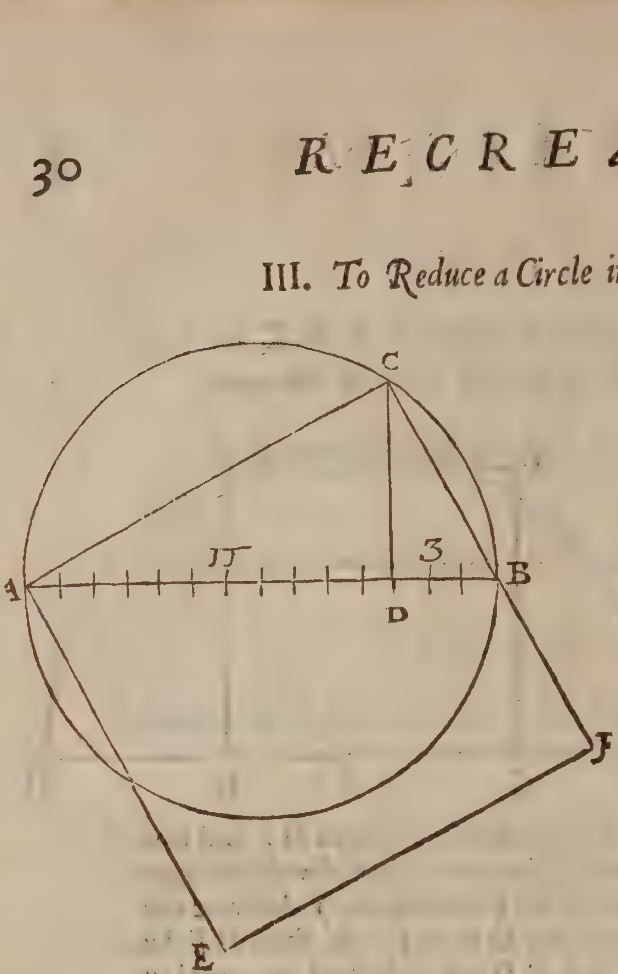
II. *To Reduce a Triangle into a Geometrical Square.*




LET L M N be a Triangle given to be reduced into a Square.

Draw a line at pleaſure, as L R, then take the length of the Baſe of the Triangle L N, and ſet it from L to N; then take half the length of the Perpendicular P O, and ſet it from N to R, and upon N erect the Perpendicular N Q; then divide the line L R into two equal parts at S, and upon S as a Center, with the diſtance S L or S R, deſcribe the Semicircle L Q R, cutting the Perpendicular N Q in Q; ſo ſhall Q N be the ſide of a Geometrical Square, equal to the Triangle M L N.

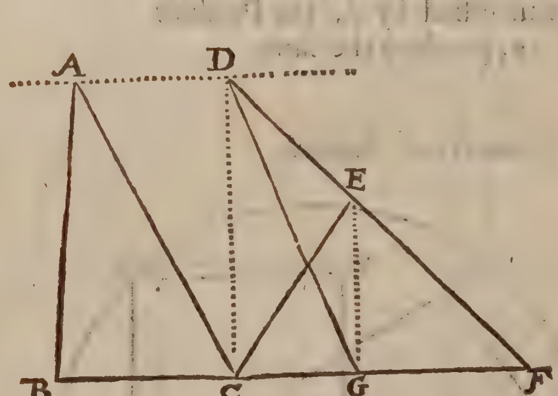
### III. *To Reduce a Circle into a Geometrical Square.*




LET ABC be a Circle given to be reduced into a Geometrical Square.

Divide the Diameter of the Circle A B into 14 equal parts, at 11 of them, as at D, erect a Perpendicular D C, cutting the Circumference in C; then draw the line A C, which shall be the side of a Square A C E F, equal to the Circle A B C.

### IV. *Two Triangles of different heights being given, to reduce them to one height.*



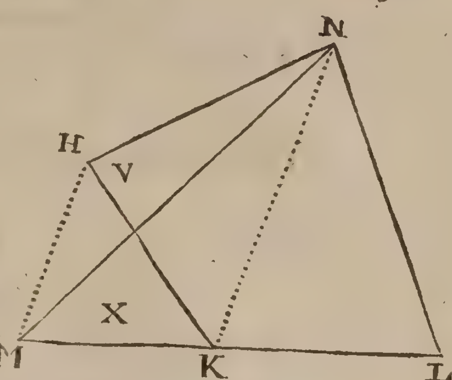

LET there be two Triangles A B C, and C E F, and let it be required to reduce the Triangle E C F into another Triangle that shall be equal in height with the Triangle A B C.

First, Through the point A draw a line A D, parallel to the bases of the two Triangles, *viz.* B F; then extend the side E F of the Triangle C E F, till it cut the Parallel line in D, and draw D C; then through the point E draw the line E G parallel to D C. Lastly, draw the line D G, so shall you have a new Triangle D G F, equal to C E F, and of equal height with the Triangle A B C.

### V. *How to Reduce an irregular Figure of Four sides into a Triangle, from an Angle given.*

LET

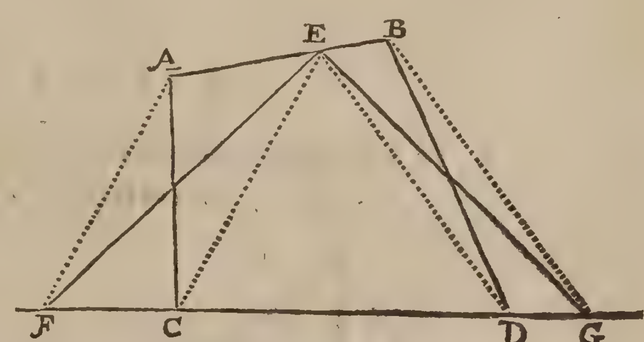
LET HKLN be a *Tropezia*, or a Figure of Four unequal Sides and Angles, and let it be required to reduce the same into a Triangle, by a Line drawn from the Angle N.




Extend the side KL, which is opposite to the Angle N, towards M, and from N draw a line to the opposite Angle M, as N K; then through the point H draw the line H M parallel to N K: Lastly, draw the line N M, so shall you have a Triangle L M N, equal to the irregular Figure H K L M; for the Triangle V, left out in the irregular Figure, is equal the Triangle X, which is taken into the Triangle.

## VI. *To reduce an irregular Figure of Four sides into a Triangle, by a line drawn from a Point limited in any of the sides thereof.*

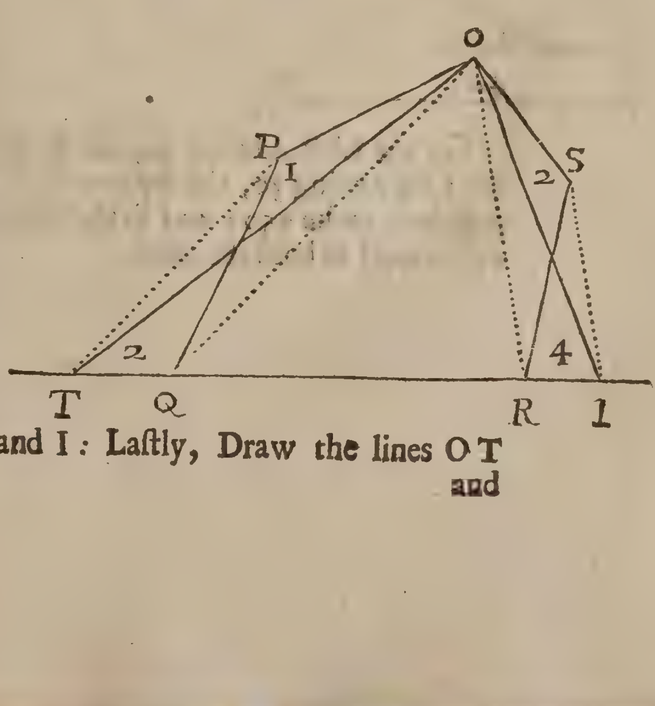
LET ABCD be an irregular figure, and it is required to reduce the same into a Triangle, by lines drawn from the point E, in one of the sides thereof.




From the given Point E draw two lines to the two opposite Angles, as the lines E C and E D, and extend the side C D, opposite to the given point E, out on both sides towards F and G; then through the point A draw the line A F, parallel to E C, and the line B G parallel to E D, cutting the side C D (extended) in the Points F and G: Lastly, draw the two lines E F and E G; so shall you have a Triangle E F G, equal to the irregular figure A B C D.

## VII. *To Reduce an irregular figure of Five sides, into a Triangle, by lines drawn from any of the Angles thereof.*

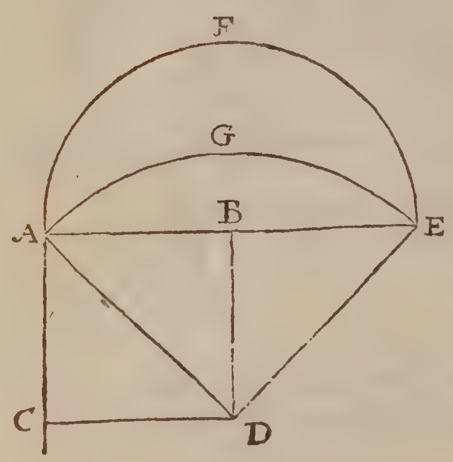
LET OPQRS be the figure given, and let it be required to Reduce it into a Triangle, by lines drawn from the Angle at O.




First, Prolong the side QR, opposite to the given Angle at O, both ways, towards T and I; and from the Angle O draw the lines O Q and O R; also through the Angular point P and S, draw the lines P T and S I, parallel to O Q and S R, cutting the side QR (extended) in the points T and I: Lastly, Draw the lines O T and

and O I; ſo ſhall you have a Triangle O T I, equal to the five ſided figure O P Q R S.

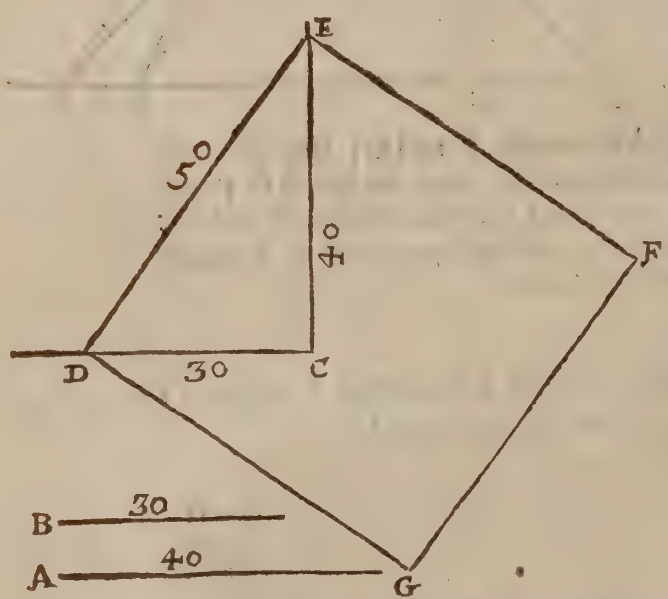
### VIII. *To Reduce a Geometrical Square into a Figure of a Lunary Form.*




LET A B C D be the Square given; firſt draw the Diagonal line A C, and on the end thereof at C erect the Perpendicular E C, making it equal to A C; then continue the ſide of the Square A B to E; and on B, as a Center, with the diſtance B A or B E, deſcribe the Semicircle A F E. Laſtly, On the point C, and diſtance C A, deſcribe the Arch A G E, leaving the Lunary Figure A F E G, equal to the Geometrical Square A B C D.

## ADDITION.

### I. *To add two Geometrical Squares together, and to give the Sum of them together in one Square.*




LET the two lines A and B be the ſides of the two Geometrical Squares, the one being 30, the other 40, of any Meaſure.

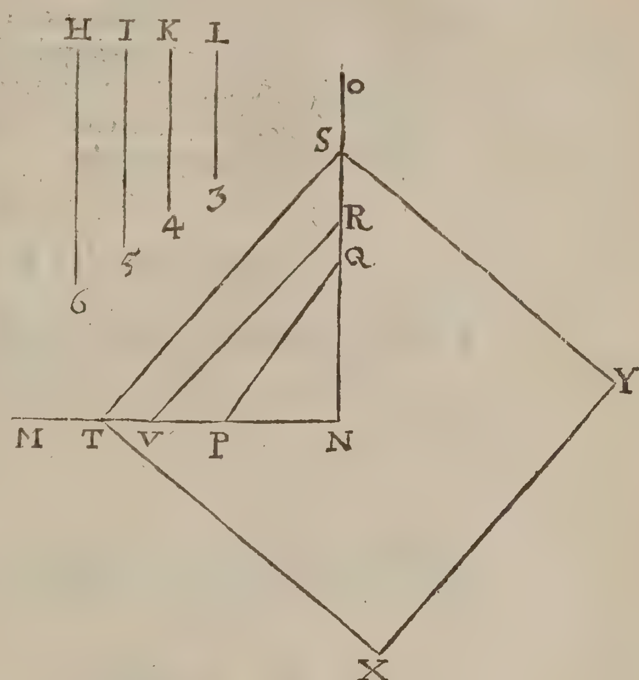
Firſt, Join two lines D C and E C together, making a right angle at C: Then take the line B in your Compaſſes, and ſet it from C to D; alſo take the line A in the Compaſſes, and ſet that from C to E, and draw the line E D, ſo ſhall E D, be the ſide of the Square D E F G, which ſhall be equal to both the Squares made of the lines A and B.

For the Line A being 40, the Square made thereof will be 160; and the Line B being 30, the Square made thereof will be 90; which added together, make 250; and ſo the ſide E D being 50, the Square thereof is 250, equal to both the other.

II. *To*

### II. *To add Two, Three, or Four Squares together, and to give their Sum in one entire Square.*

LET HIKL be four lines given, equal to the ſides of four ſeveral ſquares.



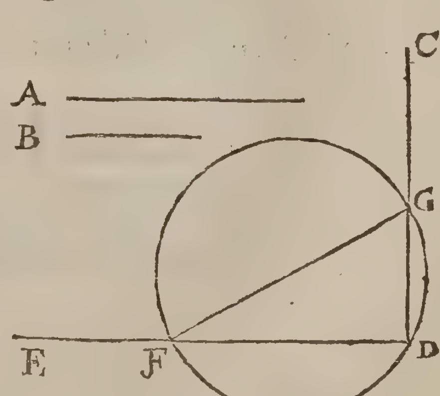

Firſt, Join two lines M N and N O together, ſo as to make a right Angle at N; then take the line L, and ſet it from N to P, and take the line K, and ſet it from N to Q, and draw the line Q P, which ſhall be the ſide of a ſquare equal to the ſquares of L and K.—Then take the line Q P, and ſet it from N to V, and the line I and ſet it from N to R, and draw the line R V, which ſhall be the ſide of a ſquare, equal to the ſquares made of the lines L, L and I. —— Then take the line R V, and ſet it from N to S, and the line H, and ſet it from N to T, and draw the line S T, which is the ſide of the ſquare S T X Y, and is equal to the four ſquares made of the lines H, I, K, and L; which I thus prove by Numbers.

| | | | | | |
|---|---|---|---|---|---|
| The Line | H | is | 6 | Whoſe Square is | 36. |
| | I | | 5 | | 25. |
| | K | | 4 | | 16. |
| | L | | 3 | | 9. |
| | | | | Their Sum is | 86. |

And the Square Root of 86 is $9\frac{27}{100}$, and ſomewhat more, for 9. 27 multiplied in it ſelf, produceth for its Square 85. 93, which is too little; and the Square of 9. 28 will be, 86. 12, ſomewhat too much.

### III. *To add two (or more) Circles together.*

LET the lines A and B be the Diameters of two Circles to be added together.




Make a right Angle by the two lines C D and E D; then take the line A, and ſet it from D to F, and take the line B, and ſet it from D to G, and draw the line G F, which ſhall be the Diameter of a Circle equal in Area or Content of two Circles deſcribed upon the Diameters A and B.

In this manner may you add Three, Four, or more Circles together.

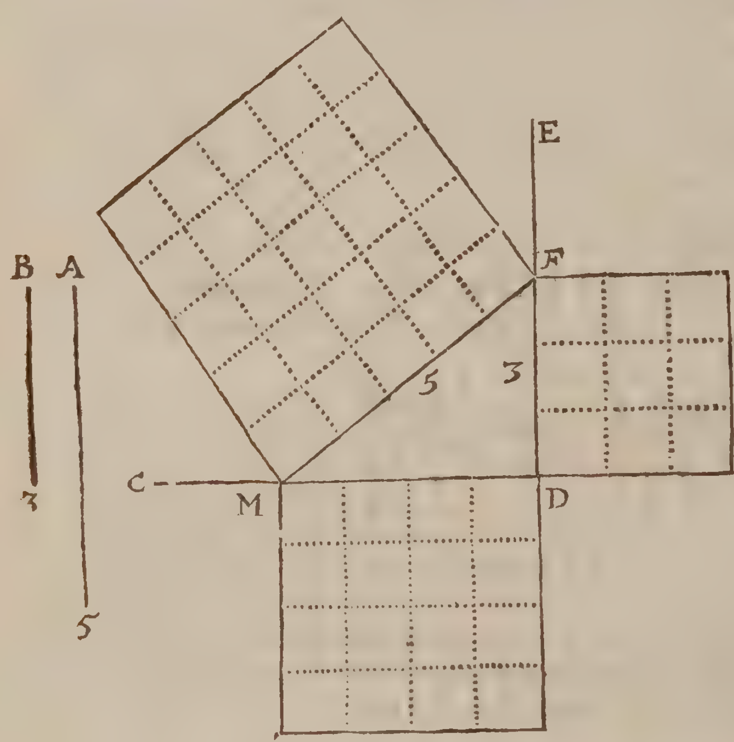
If you would add 2, 3, 4, or 5 Triangles together, you muſt firſt reduce them to Geometrical Squares, and then add them; as before is taught.

Alſo if they be Long Squares or Parallelograms, firſt reduce them to Geometrical Squares, and then add them.

If the figures to be added be of divers kinds, as a Long Square, a Circle, a Triangle, an Irregular Figure of four or five ſides, you muſt then firſt reduce your figures of 4 or 5 ſides into Triangles, and thoſe Triangles into Geometrical Squares, and then add them, as hath been already taught.

## SUBSTRACTION.

I. *Two Geometrical Squares being given, to ſubſtract the Leſſer from the Greater, and to give the Remainder in a third Square.*




LET A and B be the ſides of two Squares, and let it be required to ſubſtract the ſquare of B from the ſquare of A.——Firſt, Join two right lines, C D and E D in a right Angle in D; then take the leſſer line B, and ſet it from D to F; then take the greater line A, and ſetting one foot of the Compaſſes in F, with the other mark the Point M in the line C D, and draw the line F M.

Then have you a Triangle F M D, of which the ſide D M, equal to the line B, is 3, and the ſquare raiſed thereon contains 9 little ſquares; and the ſide M F equal to the given line A, which is 5, and the ſquare raiſed thereupon contains 25 little ſquares; then ſubſtract the ſquare 9, from the ſquare 25, and there is left 16 for the remaining ſquare, for 4 times 4 is 16, as 3 times 3 is 9, and as 5 times 5 is 25.

If divers ſmall ſquares be to be ſubſtracted from one greater ſquare, the little ones muſt be all reduced into one, and then ſubſtracted, as in this Example.

Alſo, if Circles, Triangles, or other figures be to be ſubſtracted, they muſt firſt be reduced, and then dealt with as before.

MUL-

## MULTIPLICATION.

Multiplication in Geometry, is nothing elſe but to find the Square that is made of any Line (or Number) multiplied in it ſelf.

Or to find the Rectangle or Parallelogram made of any two Lines or Numbers involved one into the other.

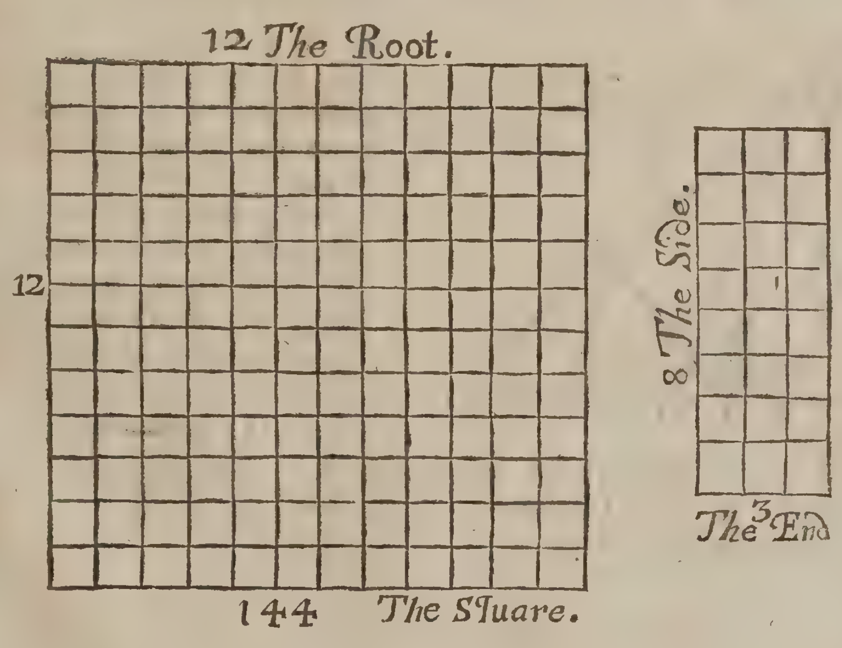
Example 1. *Let the Number 12 be given, to be multiplied in it ſelf.*

Now 12 multiplied in it ſelf (that is, by 12) produceth (or the Product is) 144; ſo that 144 is the Square, and 12 the Root thereof. And ſo of any other ſingle Number in it ſelf produceth a Square Number.

Example 2. *Let there be two Numbers 8 and 3 to be multiplied together.*

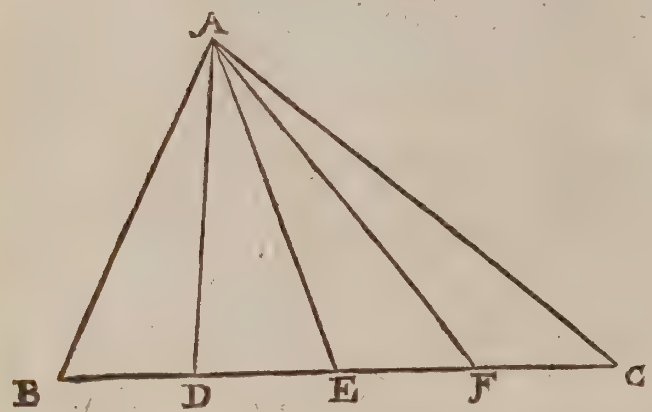
Now if you multiply 8 by 3, the Product is 24, which in Geometry is called a Rectangle, and 24 is the ſuperficial Content or Area thereof, and 8 and 3 are the two ſides thereof.

Which in Geometrical Figures will be as follows;



## DIVISION.

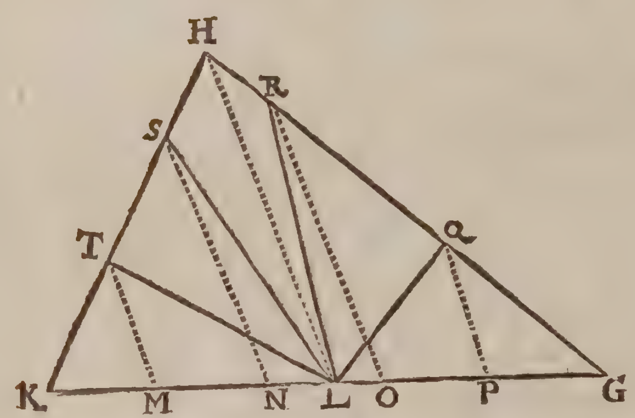
I. *To divide a Triangle into any number of equal parts, by Lines drawn from any Angle thereof.*




LET ABC be a Triangle to be divided into four equal parts, by lines drawn from the Angle at A.

First divide the ſide B C, which is oppoſite to the Angle A, (from whence the diviſion is to be made) into four equal parts, in the points D, E, and F; then if you draw the lines A D, A E and F, you ſhall have four Triangles A B D, A D E, A E F, and A F C, all of them equal one to another, and all of them together equal to the given Triangle A B C.

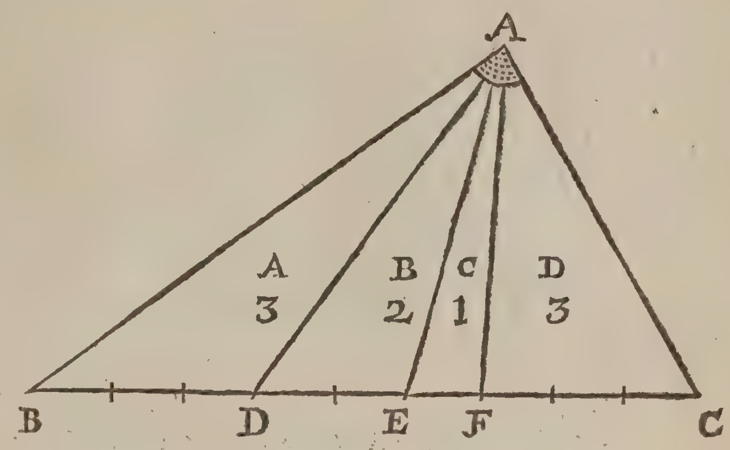
II. *To divide a Triangle into any number of equal parts, by lines drawn from any Point taken in any of the Sides thereof.*




LET GHK be the Triangle to be divided into five equal parts, by Lines drawn from the Point L in the ſide K G.

Firſt, divide the ſide G K, in which the point of diviſion is, into five equal parts, in the points M, N, O, and P; and from the point of diviſion at L, draw a right line to the oppoſite Angle H; then through the ſeveral Points M, N, O, and P, draw lines all parallel to the line L H, as the lines M T, N S, O R, and P Q; by which the whole Triangle is divided into five equal parts.

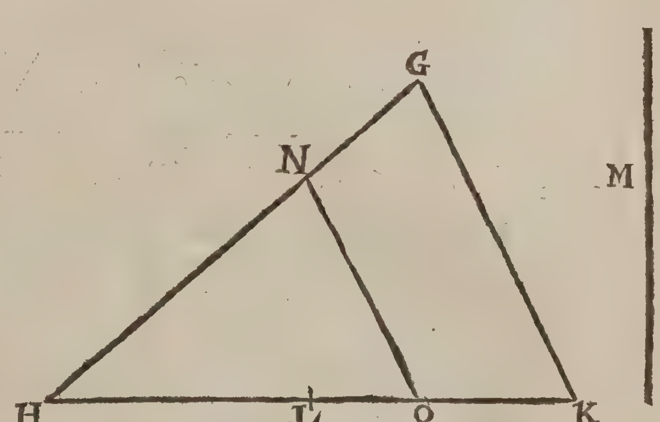
### III. *How to divide a Triangle into Two, Three, or Four, (or more) unequal parts.*




LET the Triangle A B C be a Piece of Ground containing Nine Acres, and it is let out to four men, A B C and D, of which A is to have 3 Acres, B 2 Acres, C 1 Acre about the middle, and D 3 Acres, and their lines of ſeparation are to be made from the Angle at A, there being a Pond to accommodate all the Tenants.

Firſt, Divide the ſide B C, which is oppoſite to the points from whence the diviſion is to be made, into 9 equal parts; then (becauſe A is to have 3 Acres) count three of the parts (or diviſions) from B to D, and draw A D, ſo is A B D 3 Acres, the ſhare for A. ——Then count two parts more from D to E, and draw E A, ſo is A D E 2 Acres for B. ——Then count one diviſion from E to F, and draw A F; ſo is E A F one Acre for C his ſhare; and the reſt, F A C, being three Acres, is the ſhare for D; in all, Nine Acres.

### IV. *How to divide a Triangle into two or more equal or unequal parts, by a Line drawn Parallel to any ſide thereof.*




LET G H K be a Triangle given, to be divided into two equal parts, by a line drawn Parallel to any one ſide thereof, as the ſide G K.

Firſt, divide the ſide K H into two equal parts in L; then by the Introductory Problem find a Mean Proportional Line between the whole Baſe H K and H L, which line will be found to be the line M, which line M ſet from H to O, and through O, draw the line O N, parallel to G K; ſo ſhall the Triangle be divided into two equal parts, by the line N O.

## The GOLDEN RULE,

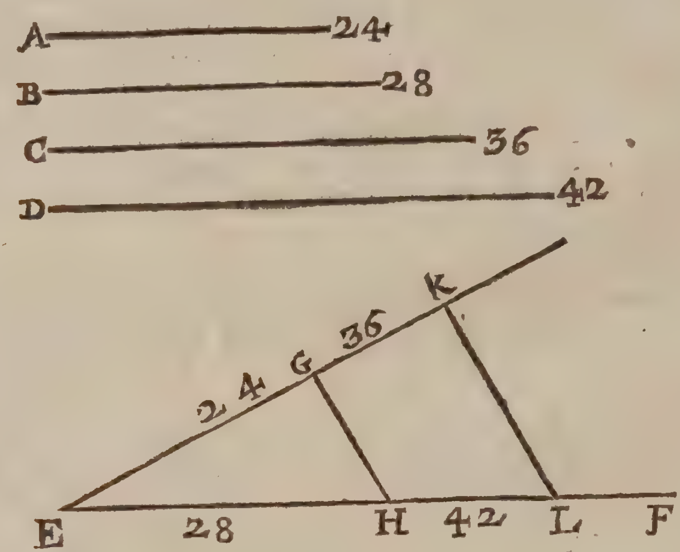
### Or *Rule of Three.*

TO work the Golden Rule, or Rule of Three, Geometrically, is, by having of Three Lines (or Numbers) given, to find a Fourth Line (or Number) that ſhall be in Proportion to them; that is,

As the Firſt Line (or Number)
Is to the Second Line (or Number),
So is the Third Line (or Number)
To a Fourth Line (or Number).

Therefore,

*Having Three Lines (or Numbers) given, let it be required to find a Fourth that ſhall be in Proportion to them.*




LET the Three Lines given be A 24, B 28, and C 36, of any Meaſure), and let it be required to find a Fourth Line D, which ſhall be in Proportion to them.

Firſt, Draw two lines, as E M and E F, making any Angle, as the Angle D E F; then take the line A in your Compaſſes, and ſet it from E to G; then take the line B, and ſet it from E to H, and draw the line G H; then take the third line C in your Compaſſes, and ſet that from E to K, upon the line E M, the ſame where the firſt line A was ſet; and through the point K draw the line K L Parallel to G H, cutting the line E F in the point L; ſo ſhall the line E L be the Fourth Proportional Line required.

For,

For,

As the Line A, equal to E G 24,
Is to the Line B, equal to E H 28;
So is the Line C, equal to E K 36,
To the Line D, equal to E L 42.

And so,

If 24 Yards of any Commodity cost 28 Shillings, what shall 36 Yards of the same cost at that rate?

Thus, as in Vulgar Arithmetick, if you multiply the second number 28, by the third number 36, and divide the Product by the first number 24, the Quotient will be 42 for the fourth number sought; and so many Shillings will 36 Yards cost.

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## CHAP. IV.

### *Of* Altimetria, Longimetria, *and* Planometria.

Shewing how to take all manner of *Heights*, *Depths*, and *Distances*, whether Accessible or Inaccessible, and to *Measure Land* Mechanically.

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### Sect. I. *Of* Altimetria, *or Measuring of Heights.*

#### PROBL. I.

*How to take the Height of any Tree, Steeple, or other Upright Building, by the Shadow thereof.*

FIG. I.

LET A B be the Wall of some Castle or Watch-Tower, and the Sun shining casts the Shadow thereof upon the Level Ground to C; now having a Walking-staff in your hand, set that upright at the end of the shadow of the Wall at C, and I find that the staff casts its shadow to E, where I make a mark, as also another at C; then measuring the length of my staff, I find it 38 Inches, and the length of the shadow of it C E, to be 46 Inches: Then measuring the length of the shadow of the Wall of the Tower A C, I find that to be 30 foot, which is 360 Inches. Now for the Height of the Castle-Wall, you must work by the Rule of Proportion, thus:

As C E, the length of the shadow of the staff, 46 Inches,
Is in Proportion to the length of the staff C D, 38 Inches;
So is A C, the length of the shadow of the Wall, 360 Inches,
To 297. 4 Inches, for the Height of the Castle Wall.

For

For if you multiply 360, by 38, the Product will be 13680; which divided by 46, the Quotient will be 297. 4 Inches *fere*, for the Height of the Castle Wall B A, which is 24 Foot and 9 Inches, and somewhat more.

## PROBL. II.

*How to take the Height of a* Watch-Tower, *by the Shadow, when you cannot come to the bottom of it, to measure the length of the Shadow.*

### FIG. II.

LET A B be a Watch-Tower, whose Height I would know by the shadow thereof, but there is a Moat about it, as B C, so that I cannot come to measure the shadow thereof: However,

I come near to the Moat-side, and there I find the shadow of the top of the Tower, to cast at C, where I erect my staff C G, and that casts its shadow to H; I measure the length of my staff, and I find it 4 foot, or 48 Inches; and the length of the shadow thereof C H, I find to be 32 Inches, these two I note down.

Then, some time after, (when the Sun is lower) I come again to the place, and find the shadow of the top of the Tower to cast at D, where again I erect the same staff of 4 foot long, and find that it casts its shadow to E, and that the length of the shadow thereof, D E, is 4 foot 5 inches, or 53 inches, and somewhat better; this I also set down, and then I measure the distance between the two places where the Tower casts its shadow, at the first and second time of my observation, namely the distance C E, and find it to be 10 foot, or 120 inches.

And now having all these numbers set down, I come to find the Height of the Tower A B, by help of the Rule of Proportion, as followeth.

(1.) As D E, the length of the shadow of the staff D F at the second Observation, 53 Inches,
Is to 48 Inches, the length of the staff;
So is 10 foot (or 120 Inches) the length of the shadow between the two places of Observation C and D,
To 108 Inches, or 9 foot.
Which number 9 foot, or 108 Inches, set down,
And say again by Proportion,

(2.) As 48 Inches the length of the staff G C,
Is to 10 foot (or 120 Inches) the distance between the two places of Observation C and D;
So is 108 Inches, (the Number before found)
To 270 Inches, the Height of the Tower; which reduced into Feet is 22 Foot, 6 Inches.

## PROBL. III.

*How to take the Altitude of any upright Building, or the like, by a Bowl of Water.*

### FIG. III.

TRavelling along the Road I see a May-pole, as K L, the height whereof I would gladly know, but having no Geometrical Instrument, I procure a Bowl of fair Water, which I set down upon the ground,

ground at M. And then, when the Water is ſtill in the Bowl, I go backward in a right line from the May-Pole, till I ſee the ſhadow of the top of the May-Pole in the middle of the Water, which I do when I come at N; and at N, I make a mark upon the ground; then do I meaſure the diſtance from the foot of the May-Pole at L, to the Bowl of Water at M, and find it to be 175 Inches: Alſo I meaſure the diſtance from the Bowl of Water at M, to the place of my ſtanding at N, and find that to be 72 Inches: Then I meaſure the Height of my eye from the Ground O N, and find that to be 60 Inches: Theſe things known, I ſay by the Rule of Proportion,

If 72 Inches diſtance M N, give 60 Inches Altitude N O;
What Altitude ſhall 175 Inches the diſtance L M give?
Anſwer $145\frac{60}{72}$ Inches.

For if you multiply 175 by 60, the Product will be 10500, which divide by 72, the quotient will be $145\frac{60}{72}$, that is almoſt 146 Inches, which is 12 foot 2 Inches for the height of the May-Pole K L, required.

### PROBL. IV.

*How to take the Height of any upright Building that is approachable, by two Sticks or Rulers joined together Square-wiſe.*

### FIG. IV.

LET P Q be ſome Structure, ſtanding upright upon plain Ground, whoſe height you require.

Go unto ſome convenient *Court, Yard, Garden,* or other piece of level Ground adjoining to the building to be meaſured, then take your Square in both your hands, holding it perpendicular, which you may do, by having a Thread and Plummet as T V, hung upon a pin near the top of the Square at T; then keeping it in this poſture, go backwards or forwards (as occaſion requires) till your Eye being at X, you can ſee the other end of your Square at T, and the Top of the Building at P, all in one Right Line, which when you do, make a ſtand, as at S; Then meaſure the height of your eye from the Ground X S, with a ſtring, and ſet that length upon the ground from the place of your ſtanding at S, to R: Then meaſure the diſtance from R to Q, for that ſhall be equal to the height of the building P Q, and is here 210 foot.

## SECT. II.

### *Of* Longimetria; *or Meaſuring of Diſtances.*

### PROBL. I.

*How by the help of this Square, ſtanding upon a Platform of a known height, to find the diſtance from the Platform to any Tree, River, or other Object that is remote from you.*

### FIG. V.

LET A B be a Platform, whoſe Perpendicular height is 100 foot, being upon the top thereof at A, I would know how far the Oak at C, is diſtant from the bottom of the Platform at B.

Upon the top of the Platform at A, I erect a Pike or Javelin 12 foot long,

long, more or leſs, upon which I hang the Angle of my Square: And I look with my eye at D, along the ſide of my Square, till I ſee the bottom of the Oak at C, and in this poſition I fix my Square, with a Screw or the like, to the head of the Javelin: Then from D I extend a thread or Line by the ſide of my Square, till it touch the Platform at E, and then I meaſure the diſtance upon the Platform from A to E, and find it to be 24 foot, 6 inches; then by Proportion I ſay,

As 12 foot, the length of the Javelin, D A,
Is to 24 foot and a half, the diſtance meaſured upon the Platform A E,
So is 112, the height of the Platform and Javelin together, B D,
To 228 foot, 8 inches, for the diſtance B C.

## PROBL. II.

*How to take the diſtance from the place of your ſtanding upon level Ground, to any Tree, Tower, or other thing, remote from you, tho you cannot come near the ſame, by your Square.*

### FIG. VI.

STanding at F, I ſee a Conduit head at G, whoſe diſtance from F where I ſtand, I would know, but I cannot come near it for a River between F and G: However,

At F I erect a ſtaff of 4 foot high, (or 48 Inches) as F H, upon the end whereof I hang the Angle of my Square, and I look by the ſide thereof, till I ſee the foot of the Conduit-head at G, and fixing my Square there, I extend a line from H, by the ſide of the Square, till it touch the Ground at K: Then meaſuring the diſtance between F and K, I find it to be 3 foot, or 36 Inches: Then by the Rule of Proportion I ſay,

As 36, the diſtance K F,
Is to F H, the length of the ſtaff, 48 Inches;
So is 48 inches, the length of the Staff F H,
To 64 inches, for the Diſtance F G.
For as often as K F is contained in F H,
So often is F H contained in F G.

## PROBL. III.

*How to take the Breadth of a River by the Square.*

### FIG. VII.

THere is a River M P O, whoſe breadth I deſire to know: Upon the brow of the River at M, I ſet up my Staff M L, which is 60 inches (or 5 foot) long, and hanging my Square upon the end thereof at L, I look by the ſide thereof, till I ſee the Brow of the River on the other ſide at O, and there fixing my Square, I extend a Thread by the ſide thereof, from L to N, then meaſuring the diſtance L N, I find it to be 15 inches (or 1 foot 3 inches); then I ſay by Proportion,

As N M, the diſtance meaſured, 15 inches,
Is to L M, the length of the Staff, 60 inches.
So is L M 60 inches,
To M O, 240 inches, (or 20 foot) for the breadth of the River M O.

PROBL.

## PROBL. IV.

*How to take an inaccessible* Distance, *by three flat* Sticks *or* Rulers *of equal* Length, *joined together, thereby making an* Equilateral Triangle: *As in*

### FIG. VIII.

LET A be a Tree or other Object, whose distance you would know from the place of your standing at B, there being a River or the like Impediment between you and the Tree.

Place your Triangular Rulers horizontally upon a staff at B, and observe the Object at A by the side of the Triangle B D; it so resting, look at some other Object (or cause one to be set up) by the side of the Triangle B E. Then transfer your Triangle along the line B C, and place it upon divers parts of the same line, till at length you find a Point C, upon which placing the Triangle, you shall see the Point B, by the side C G, and the Object A, by the side C F; then I say the lines C B and C A are equal; so that by measuring the line B C, you have the Distance from B to A.

## PROBL. V.

*How to take the Distance between Two (or more) Places, without coming near any of them, by a Two Foot Joint Rule.*

### FIG. IX. and X.

LET the two remote Places given be A and B, whose distance I would know, but I cannot approach or come near either of them; and I have no other Instrument but my Two-Foot Joint Rule; however, I make choice of a Place at C, from whence I can see both the Places, A and B, and thered set up a staff whereon to rest my Rule, and opening it to a Square Angle, I look by one side of it, till I espy my first place at A, and there keeping it fast and level, I look by the other side of the Ruler, and cause a Mark to be set up in a right Line from C, at a competent distance from C, as at D, 150 foot; then close in your Rule, till by the side thereof you see your second place at B; keep your Rule at that Angle:

Then having a sheet of Paper, or upon a Board, as Figure IX. draw two Right Lines thereon, as K L, and L M, making a Right (or Square Angle) at L.

Then bring your Ruler, (it being still kept at the Angle it was when you looked to B) and lay the Center of your Ruler upon L, and by the side of it draw a line L M; and because your measured distance between C and D was 150 foot, take 150 quarters of Inches (150 of any equal parts that you have upon your Ruler) and set them down upon your Paper or Board, from L to M.

Then take your Rule and go to D, and set the Center of it upon the Staff, look by one side thereof to C, and by the other to A, then bring the Rule to the Board, and lay the Center thereof on M, and one side upon the line M L, and by the other side draw a line at length, as the line M O, crossing the line L K in O; so shall O upon your Board represent the Place A in the Field: Again, Take your Rule, and go to D, and there resting it upon the Staff, look by one edg to A, and by the other

to B, and keeping it at that Angle, bring it to the Board, and lay one side upon the line M O, and by the other draw the line M P, crossing the line L N in the Point P, so shall P represent upon the Paper the second Place B in the Field, and being measured upon the same Scale whereof L M was measured, it will be found to be 250 foot, and that is the distance from A to B. And by this means you may find the distances of all the Places in the Figure, if you measure them upon the same Scale as L M, or O P were measured, and so shall you find

$$\text{The Distance} \begin{cases} \text{L O} \\ \text{L P} \\ \text{M O} \\ \text{M P} \end{cases} \text{to Contain} \begin{cases} 128 \\ 317 \\ 200 \\ 220 \end{cases} \text{Foot.}$$

### PROBL. VI.

*How to take the Distance between One or more Places, by a Ten Foot Rod (divided into Inches) only.*

### FIG. XI, and XII.

STanding at A, I would know how far it is to the Tree at B, tho I cannot come near it.

Standing at A, I measure in a right line from thence 30 foot, from A to *a*: And looking towards D, I measure out 30 foot more, as from A to C; and measuring the distance *a* C, I find it to be 25 foot, which laid down upon Paper, do make the Triangle A C *a*, of which draw the line A *a* out at length.

Then standing at C, I measure in a right line towards B, 25 foot, from C to *b*, and the distance between *a* and *b*, I measure to be 20 foot, which makes the Triangle C *a b*, Draw the side C *b* at length, till it cross the former line A *a*, extended in B; so shall the line A B (being measured by the same Scale that the other Lines were laid down by) be found to contain 82 foot, and such is the distance between A and B.

And according to this Method may the distances from several Places be measured, As in Figure XI. Where standing at G and H, you may find the distance between E and F; and also all the other intermediate distances, as from G or H, to E or F, as also the distances G E, G F, H E, H F, *&c.* as by *Figure* XII. is evident.

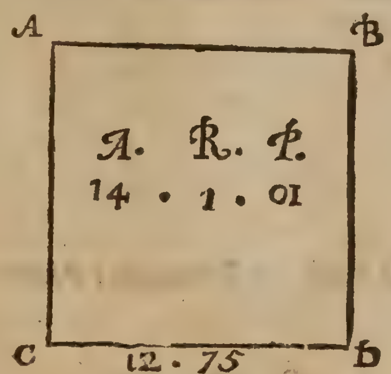
## SECT. III.

### *Of* Planometria: *Or Land-Measuring Mechanically.*

FOR the Measuring of Land (by a Chain only without any other Graduated Instrument, which I call) Mechanichally: The best Chain that I can advise you to, is one that is commonly known by the name of *Gunter*'s Chain, and it contains in length four *Rods*, *Poles*, or *Perches* (which are all one), and each Pole contains 16 foot and a half: So that this Chain is 66 foot in length, and is divided into 100 equal Parts or *Links*, which are distinguished by having a Brass *Ring* at every Ten Links end: And one of these *Chains* in *Breadth*, and *Ten* of them in *Length*, do make One just *Acre* of Land according to the Statute: And thus

thus much concerning the *Chain* it ſelf. ——And now, before I come to ſhew you how to take the Plot of a Field by help thereof, without any other Graduated Inſtrument, I think it convenient, firſt to ſhew you how any Piece of Land meaſured by ſuch a Chain may be caſt up; that is, to know how many *Acres, Roods*, and *Perches*, ſuch a Piece of *Ground* ſo meaſured doth contain. And in order thereunto I ſhall begin with the Menſuration of *Squares, Triangles*, &c.

### I. *To Meaſure a* Square *Piece of Land.*



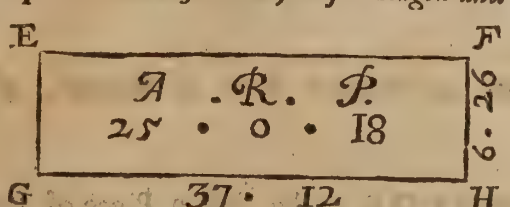

IF your Piece of Ground be exactly four Square, and have all the ſides of equal length, and at right (or ſquare) Angles, as the figure A B C D; and by your Chain you find that each ſide thereof contains 12 Chains, and 25 Links; you have no more to do, but multiply 12 C. 25 L. by 12 C. 25 L. as you ſee done in the Margent. And the Product is 1425625, from which (always) cut off five Figures towards the Right hand, by a Point or Line, and then the Product will be 14.25625; that is 14 Acres, and .25625 hundred thouſand parts of an Acre; and to know how many *Roods* and *Perches* that is, multiply .25625 by 4, (becauſe there are 4 *Roods* in one *Acre*) and the Product will be 1.02500; and five figures cut off, there is 1 beyond the Prick, which is 1 *Rood*, and .02500 remaining, which multiply by 40, (becauſe there are 40 *Perches* in a *Rood*) and the Product will be 1.00000; from which five figures being cut off, there will remain 1. which is one Perch: So that this Square Piece of Land thus meaſured, will contain 14 *Acres*, 1 *Rood*, and 1 *Perch*.

```
    12.75
    12.75
   ------
     6375
    8925
   2550
  1275
  --------
A 14.25625

   .25625
        4
  -------
R 1.02500

   .02500
       40
  -------
P 1.00000
```

### II. *To meaſure a* Square *Piece of Land, whoſe Length and Breadth are unequal.*

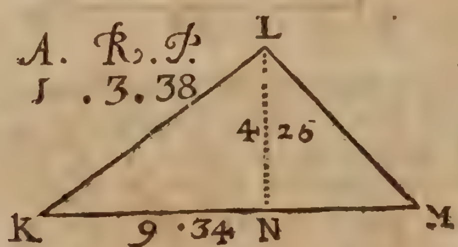



LET C D E F be a Furlong in common Field, or the like; and let the length thereof G H be 37 Chains and 12 Links, and the breadth thereof

| |
|---|
| 27.12 |
| 9.26 |
| 16272 |
| 5424 |
| 24408 |
| A. 25.11312 |
| 4 |
| R. 0.45248 |
| 40 |
| P. 18.09920 |

thereof F H 9 Ch. 26 L. Multiply 27. 12. by 9. 26, and the Product will be, five figures being cut off 25. 11312, which is 25 Acres; and the remainder 11312 multiplied by 4, the Product (five figures being cut off), is 0. 45248, which is 0 Roods: And the remainder 45248 multiplied by 40, and five Figures cut off, will be 18. 09920, which is 18 Perches; so-that this Piece of Land contains 25 *Acres*, 0 *Roods*, 18 *Perches*. As is seen in the Margent.

### III. *To measure a* Triangular *Piece of Land.*




| |
|---|
| 4.67 |
| 4.26 |
| 2802 |
| 934 |
| 1868 |
| A 1.98942 |
| 4 |
| R. 3.95768 |
| 40 |
| P. 38.30720 |

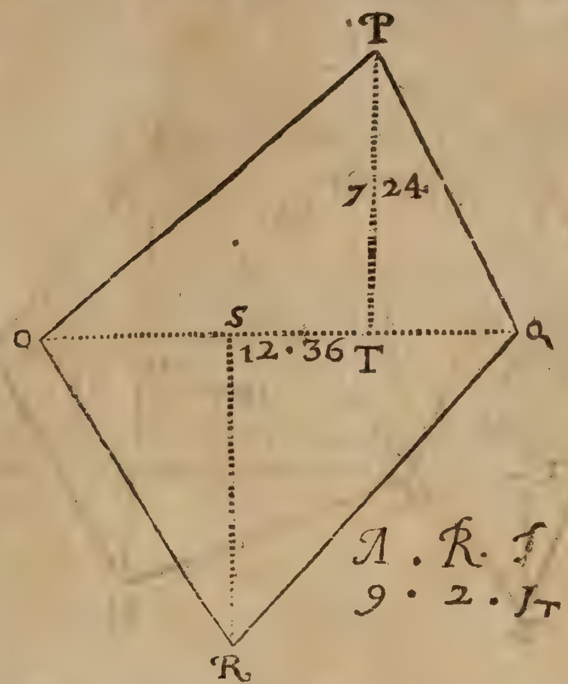
To measure Triangular Pieces of Land, you must multiply Half the length of the *Base* by the *Perpendicular*, and that Product shall give the Content of the Piece.

So in the *Triangular Piece* of Land K L M, the length of the line K M is 9 Ch. 34 L. the half thereof is 4 Ch. 67 L. this multiplied by 4 Ch. 26 L. the length of the Perpendicular L N, the Product (five figures being cut off) is 1 Acre, and .98942 remaining; which multiplied by 4, the Product is 3 Roods, and .95768 remaining; which multiplied by 40, it produceth 38 Perches, &c. as in the Margent: So that this Triangular Piece of Land contains 1 Acre, 3 Roods, and 38 Perches; which is 2 Acres wanting only 2 Perches.

### IV. *How to measure an irregular Piece of Ground, of Four unequal Sides.*

Suppose the figure O P Q R to be such a Piece of Land to be measured by the Chain only.

First




First, meaſure the Length or Diagonal thereof O Q, finding it to contain 12 Chains, 36 Links, which ſet down; then meaſure the Perpendiculars P T and R S, finding one to be 7 C. 24 L. the other 8 C. 28 L. which added together makes 15 C. 52 L. the half whereof is 7 C. 76 L. which multiplied by the length O Q, 12 C. 36 L. the Product is 9 Acres, and .59136, which multiplied by 4, the Product is 2 Roods, and .36544 remaining; and that multiplied by 40, produceth 14 Perches, &c. as in the Margent; and the whole Content of the Triangle is 9 *Acres*, 2 *Roods*, and 14 *Perches*.

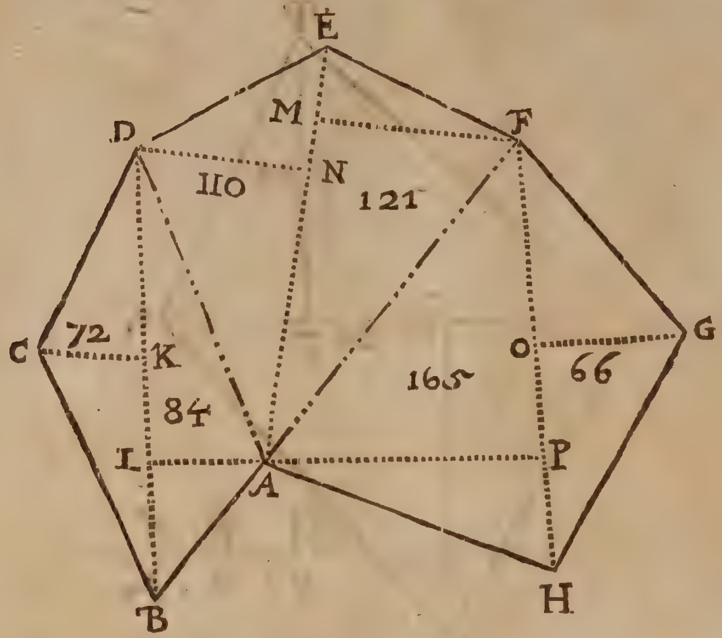
12.36<br>7.76<br>———<br>7416<br>8652<br>8652<br>———<br>A. 9.59136<br>4<br>———<br>R. 2.36544<br>40<br>———<br>P. 14.61760

V. *Of Irregular Pieces of Ground of many Sides, how to reduce them into Triangles, and to meaſure them.*

LET A B C D E F G H be a *Field* to be meaſured: In regard that the Field is irregular, it muſt therefore be firſt reduced into *Triangles* by drawing (or imagining) lines to be drawn from one Angle to another, as the lines A D, D B, A E, and F H; by which lines ſo drawn (or imagined) the whole *Figure* will be reduced into Six *Triangles*, namely,

Into the Triangle { B C D<br>A D B<br>A D E<br>A E F<br>A F H<br>F G H

These




These six *Triangles* being measured severally, according to the directions before given, the Contents of all of them added together into one Sum, will give you the Content of the whole *Piece* in Acres, Roods, and Perches.

| | | | A. | R. | P. |
|---|---|---|---|---|---|
| Suppose the Triangle | B C D | Should be found to contain | 1 | 1 | 16 |
| | A D B | | 1 | 2 | 12 |
| | A D E | | 2 | 0 | 10 |
| | A E F | | 2 | 1 | 03 |
| | A F H | | 3 | 0 | 15 |
| | F G H | | 1 | 0 | 38 |
| | | The Sum | 11 | 2 | 14 |

Which is the Content of the whole Field.

But for an Abbreviation of this Work, you need not to find the Content of every single *Triangle*, but of every *Trapezia* or *Four-sided Figure*, as is taught in the Fourth *Problem* next before going; for the *Figure* is as well divided into *Trapezias* as into *Triangles*, namely, into the Three *Trapezias* ABCD, ADEF, and AFGH; and so by this means you will abbreviate half your work; for if you measure the Three *Trapezias* severally, you shall find

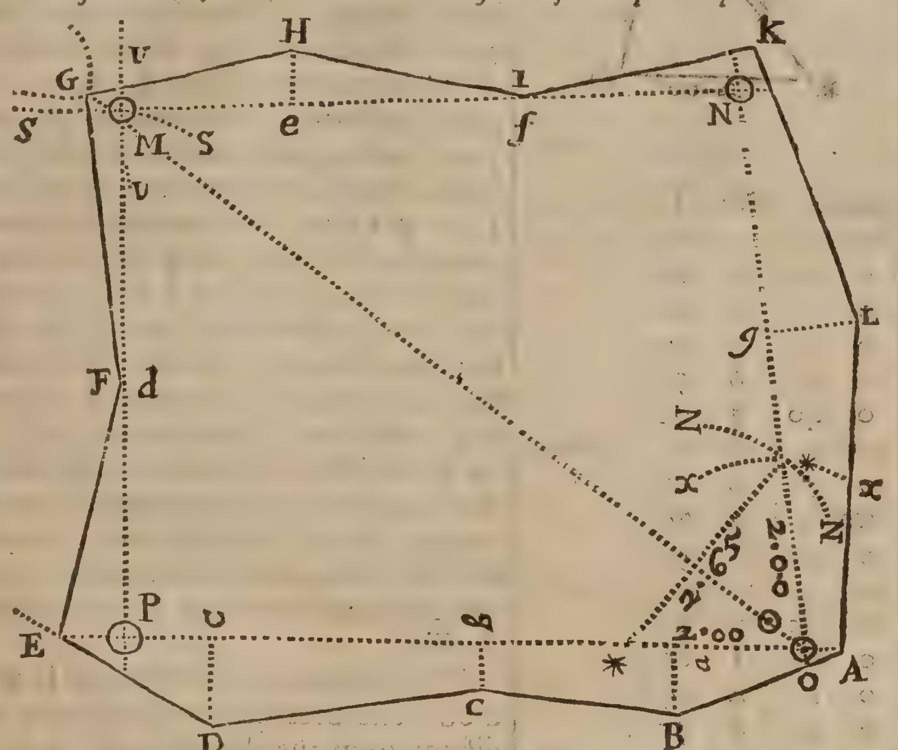
| | | | A. | R. | P. |
|---|---|---|---|---|---|
| The *Trapezia* | A B C D | to contain | 2 | 3 | 28 |
| | A D E F | | 4 | 1 | 13 |
| | A F G H | | 4 | 1 | 13 |
| | | The Sum | 11 | 2 | 14 |

*Note*, That of what *Number* of *Sides* your *Figure* consists of, the *Number* of *Triangles* into which it will be *reduced*, will (always) be less by *Two* than the Number of *Sides*: As in this *Figure*; the *Number* of *Sides* are *Eight*, and the *Triangles* are but Six; two less.

And

And thus have I done with the *Chain*, as to the deſcription of it, and how to caſt up any *Figure* or *Piece* of *Land*, *Regular* or *Irregular*, *meaſured* thereby, in *Acres*, *Roods*, and *Perches*: It reſteth now, that I ſhew you how to make uſe of it in the *Field*, in meaſuring of any Irregular Piece of Ground; and that ſhall be the Work of this next Paragraph.

VI. *How to take the true Plot of any Irregular Field of many Sides and Angles, by the forementioned Chain only, without any Graduated Mathematical Inſtrument; and to make a Plot of the ſame upon Paper or Velum.*




LET ABCDEFGHIKL, be an Irregular *Field* to be meaſured as aforeſaid.

When you firſt enter the *Field*, cauſe *Beacons* or other *Viſible Marks* to be ſet up near the principal *Angles* or *Corners* of the *Field*, as thoſe at M, N, O, and P.

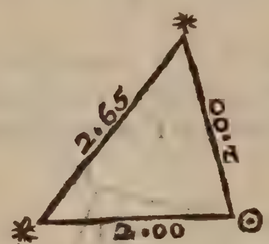
Secondly, Conſider the beſt corner to begin at (tho any will ſerve) as I make choice of that Mark at O.

Thirdly, Take out your Chain, and holding one end at the Beacon at O, meaſure out 2 Chains (or more or leſs, as you ſee occaſion) from the Beacon at O towards the Beacon at N, and at the end of the 2 Chains ſet up a ſmall Bow or Stick at *. ——Then again, from your Beacon at O meaſure 2 Chains more in a right line towards P, and there ſet up another ſmall Bow or Mark as at *. ——And then meaſure with your Chain the diſtance between your two Marks * and *, which here is 2 Chains 65 Links.

Fourthly, Prepare a Book, or Sheet of Paper, Ruled as in the Margent, to ſet down your Meaſures as you go along, but firſt at the top of it make a Triangle anſwerable to that which you meaſured out in the Field, and ſet ſuch Numbers to it as you there meaſured, as 2 Chains from ⊙ to * both ways, and 2 Chains 65 Links from * to *.

 This

This done, go into the Field to your Beacon at O, and meaſure the diſtance of it from the hedge on your left hand, finding it to be 20 Links of your Chain, which ſet down on the left hand Column of your Book, againſt 0 Ch. 00 L. becauſe the Hedge was on your left hand.




| Sets off | Ch. L. | Sets off |
|---|---|---|
| 0 20 | 0 00 | |
| 0 70 | 1 40 | |
| 0 50 | 3 40 | |
| 0 90 | 6 50 | |
| 0 40 | 7 20 | |
| 0 70 | 0 00 | |
| touch | 2 70 | |
| 0 30 | 5 50 | |
| 0 25 | 0 00 | |
| 0 60 | 1 80 | |
| 0 15 | 4 25 | |
| 0 40 | 6 50 | |
| 0 30 | 0 00 | |
| 0 95 | 2 70 | |
| 0 40 | 5 90 | |

Then with your Chain meaſure from the Beacon at O, towards that at P, in a right line, and as you go along, at the end of 1 C. 40 L. you find a Break or Bend in the Hedge, diſtant from your Chain 70 L. Set the 1 C. 40 Links in the middle Column, and the 70 L. by it; then going on farther, at the end of 3 C. 40 L. you come againſt another Break or Bow in the Hedge, diſtant from your Chain-Line 50 Links, both which ſet down in your Book: And going on, farther towards P, at the end of 6 C. 50 Links, I find another Break or Bow diſtant from my Chain-Line 90 Links, both which ſet down, and meaſure on to your Beacon at P, which will terminate at 7 C. and 20 L. which ſet down, and becauſe the Beacon at P is 40 Links diſtant from the Hedge, ſet 40 Links by the 7 C. 20 L. and draw a Line croſs your Book, to ſignify that you have done with that ſide of the Field,

Then in your Book under Ch. L. write 0 00; and becauſe your Beacon at P is diſtant from the Hedge G H 70 L. ſet that down againſt 0 00, and go on and meaſure towards the Beacon at M, and when you have meaſured 2 C. 70 L. you come to *touch* the Bow in the Hedge at F, wherefore ſet down 2 C. 70 L. and againſt it write *Touch*. Then meaſuring on to your Beacon at M, you find the length to be 5 Ch. 50 L. which ſet down, and by it 30 L. which is the diſtance of the Beacon M from the Hedge. Thus having finiſhed this ſide of the Field, draw a Line croſs your Book, as before.

And in this manner muſt you deal with the other two ſides, M N and N O, till you come where you firſt began. And this way for meaſuring of any irregular piece of Ground, is as exact as is poſſible to be performed by the beſt Graduated Inſtrument that can be made.

And

And thus having ſhewed you how to meaſure in the Field, and take account thereof in your Book, it reſteth now to ſhew you how to lay the Plot or Figure of this Field down upon Paper or Velum, in order to the finding of the *Content* or *Quantity* of it in *Acres*, *Roods*, and *Perches*.

VII. *How to lay down upon Paper or Parchment any Piece of Ground taken by the Chain as before, in order to finding the Content or Quantity thereof.*

FOR the performance of this Work, you muſt provide for your uſe a Pair of very fine-pointed *Compaſſes*, and alſo a Ruler with ſeveral *Scales* of *Equal Parts*, ſuch as is mentioned in the next *Chapter*, with a figure thereof. This Plot here deſcribed, is laid down by a Scale, that half an Inch is equal in length to one whole *Chain* of *Four Pole*; and the half *Inch* in the *Scale* is divided by *Diagonals* into 100 parts, anſwerable to the 100 *Links* into which your *Chain* is divided. Being thus provided of *Scales* and *Compaſſes*, you may begin your *Plot* in this manner.

1. Upon a *ſheet of Paper* draw a right line at pleaſure, as the line P O; towards one end thereof, as at the *Station* or *Beacon* by O, make a Mark, as ⊙.

2. With your Compaſſes, out of your *Scale* take 2 Chains, (which in this Plot is one Inch) and ſetting one foot of the Compaſſes in ⊙, the other will reach to the Point *, upon the line O P, and one foot of the Compaſſes ſtill reſting in the point ⊙, with the other deſcribe the obſcure Arch x x. Then take out of your Scale 2 Ch. 65 L. (which was the diſtance you meaſured from * to *) and ſetting one foot of that diſtance upon the Point *, in the Line O P, with the other deſcribe another obſcure Arch z z, croſſing the former in the Point *, which is upon the line O N; and through the Point * draw another right line ⊙ * N at length.

3. Theſe two Lines being drawn, repair to your *Note Book*; and therein finding your *Chain-Line* O P to be 7 Chains 20 Links, take 7 C 20 L. from your Scale, and ſet them from ⊙ to P. Alſo finding by your Book, that the Chain-Line O N did contain 5 C. 90 L. take that alſo out of your Scale, and ſet it upon the Line from O to N; then the Chain-Line P M being 5 C. 50 L. take them out of your Scale, and ſetting one foot of the Compaſſes in P, with the other deſcribe an obſcure Arch s s; and the Chain-Line M N being 6 C. 50 L. take them out of your Scale alſo, and ſetting one foot of the Compaſſes in N, with the other foot deſcribe the obſcure Arch v v, croſſing the former in the ſtation point ⊙ by M, through which Point draw the right lines P M and N M at length: And thus have you drawn upon Paper the Quadrilateral Figure M N O P, of the ſame Length and with the ſame Angles as you meaſured them with your Chain in the Field.

4. Having gone thus far, lay your *Note-Book* before you; and ſeeing that at your beginning at O, your Beacon at ⊙ did ſtand 20 L. diſtant from the Hedge, take 20 L. out of your Scale, and ſet them from ⊙ to o; alſo at 1 C. 40 L. at a, the bow of the Hedge was diſtant from the Chain-Line 70 L. take firſt 1 C. 40 L. and ſet them from O to a, and the 70 L. from a to B, and draw the line A B: Then take 3 C. 40 L. and ſet them from O to b, and 50 L. from b to C, and draw the line B C. Then take 6 C. 50 L. and ſet them from O to c, and 90 L. from c to D, and draw the line C D. Then at 7 C. 20 L. which is at the

Beacon P, ſet 40 Links to the Hedge, and through that Point draw the Line D E : So is this ſide of your Field finiſhed.

5. Begin again at the Beacon by P, where you find by your Book, that the Beacon was diſtant from the Hedge 70 L. ſet 70 L. from ⊙ to E. Then at 2 C. 70 L. you find that your Chain-Line did touch the Hedge; wherefore take 2 C. 70 L. from your Scale, and ſet them from P to F (or d) and draw the line E F; then your next length 5 C. 50 L. will reach from P to M, where the Beacon was 30 L. from the Hedge, ſet 30 L. from ⊙ to the Hedge, and through that point draw the line F G. And thus have you finiſhed your ſecond ſide: And in the ſame manner you muſt deal with the other two ſides; and in ſo doing you ſhall have compleated your Work, and have the exact *Draught* of your Field upon a ſheet of Paper, which you may caſt up into *Acres*, *Roods*, and *Perches*, by the Directions given in the preceding Third *Paragraph*.

And if you meaſure the ſmall Triangles, and other four-ſided Figures which are without the Chain-Lines, by themſelves, and afterwards the Quadrilateral Figure M N O P, by it ſelf, (which is the better way) you will find this Field to contain 4 Acres, 2 Roods, and 35 Perches.

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## CHAP. V.

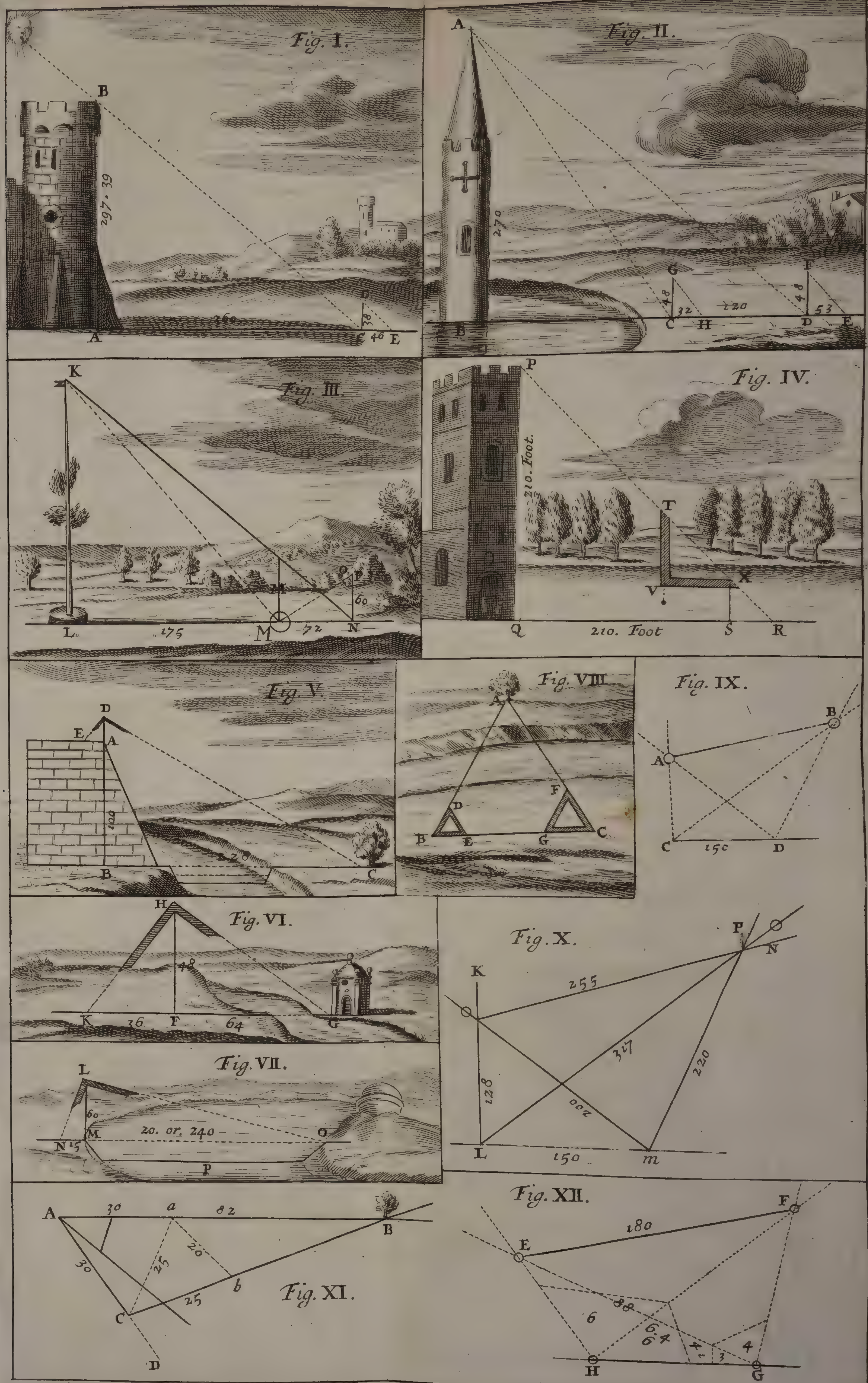
*Wherein is ſhewed how to take all manner of Heights and Diſtances; and to meaſure all manner of Land, of what kind ſoever, Inſtrumentally.*

IN the foregoing *Chapter* you are taught how to take *Heights* and *Diſtances*, and alſo to *meaſure Land Mechanically*, whereby any perſon may very well (with more labour) perform many *Geometrical Concluſions* by ſlight and common *Tools* uſed by *Mechanick Artificers*, as by *Squares*, *Joynt-Rules*, *Rods*, &c. But in this *Chapter* I ſhall ſhew more Artificially how to perform the forementioned by *Graduated Inſtruments*: And altho I have handled this Subject at large in my *Compleat Surveyor*, yet I will here give a ſufficient and exact way to do the like by an *Inſtrument* both portable and exact, not there mentioned; namely, a *Semicircle*, with its Appurtenances.

### *A Deſcription of the Semicircle.*

A *Semicircle* in *Geometry* is thus defined, *A* Semicircle *is the one half of a* Circle *cut off by the* Diameter, *and is contained under a right Line, which is the* Diameter; *and an Arch or crooked Line, which is called ſometimes the* Circumference, Perifery, *or* Limb.

The *Semicircle* which we here intend to deſcribe and ſhew the uſe of, is uſually made in Braſs, the *Diameter* whereof may contain in length about 10 Inches, the *Semidiameter* half as much; the *Diameter* and *Limb* are either of them about an Inch in breadth: The *Limb* of this *Semicircle* is divided into 180 equal parts, called *Degrees*, and every of thoſe *Degrees* is uſually divided into ſmaller equal parts, according to the bigneſs of the *Inſtrument*, (uſually into four) ſo is every ſmall diviſion or part, 15 *Minutes*. It is ſometimes divided by *Diagonals*, ſo that you may (tho the



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the Instrument be small ) take off every third or fourth Minute. These Degrees are numbred from the left hand towards the right, by 10, 20, 30 *&c.* to 180; and back again from the right hand towards the left, by 190, 200, 210, *&c.* to 360.

Upon the *Centre* of this *Semicircle* is placed a round *Box* of Brass, in the bottom whereof is a *Chard*, having upon it the 32 points of the Mariners Compass, and over it a *Needle* covered with Glass; this *Needle* is at any time to set the *Diameter* of the *Semicircle* due *North* and *South*, or according to any other *Coast*.

Between the *Semicircle* and this *Box* is an *Index*, which moves upon the *Centre* of the *Semicircle*, and is of sufficient length to cut at either end thereof the *Degrees* on the *Limb* of the *Semicircle*. It hath upon it two *Sights*, through which you may look either backward or forward, to any *Mark* or *Object*.

On the backside of the *Semicircle* is screwed a *socket*, into which goeth another *socket* called a *Ball-socket*, which serveth to set the *Semicircle* when it is upon the *Staff* in any position whatsoever, as *horizontal* or *level*, *vertical* or *perpendicular*, or *reclining*, or *inclining* to any Angle.

Into this *Ball-socket* there goes the head of a *three-legged staff*, which supporteth the *Instrument* in the field.

These are all the parts of the *Semicircle*, as it is to be used in the fields to make observations; but to lay down your Work at home, there belongeth,

1. *A Protractor.*
2. *A Scale.*
3. *A Pair of Compasses.*
4. *A protracting Pin.*

1. The *Protractor* is made of a thin piece of Brass divided in all respects as the *Semicircle* was, and numbred in the same manner from 1 to 180 degrees, but from 180 degrees to 360 degrees; it ought to be numbred from the left hand towards the right, contrary to the numbering of your *Semicircle*. The use of this *Protractor* is to lay down the quantities of those Angles upon *Velum* or *Paper*, which you observe in the field.

2. Your *Scale* is a Ruler of Brass, upon which you may have what Scales you please, either *plain* or *diagonal*, as of 10, 11, 12, 16, 20, 24, 30 and 32 in an Inch; these *Scales* are to lay down the lengths of your Lines, as you measured them in the field with your Chain; and according to the largeness or smalness of your Scale, you may make your Plat or Draught of what bigness you please.

3. Your *Compasses* are to take your distances from your Scale, and to apply them to your Paper or Velum.

4. Your *Protracting Pin* is to fix in your Center Point, and also to mark the degrees on the edge of your *Protractor*.

The *Chain* which you measure your lengths in the field, may be of what length, and how you will divided; but the Chain which the Examples in this Book are wrought by, is 4 Pole in 100 Links.

The

## The Use of the *Semicircle*, in taking of *Heights*, *Depths*, and *Distances*.

### PROP. I.

*How to take the Height of any* Tree, Tower, Steeple, *or other* Object, *which standeth upright, and being accessible at one Station.*

### FIG. I.

LET A B be a *Castle-Wall*, whose height you would know; you standing at C, place your Semicircle at G, and turning it about by help of your Ball-socket, direct it to the Object; then fixing all your Sockets fast, by help of the screws for that purpose, hang a Thrid and Plummet upon the Center of your Semicircle, and move the Semicircle up and down till the Thrid and Plummet hang directly upon 90 deg. then laying the Index just upon the Diameter, there hold it, and looking through the Sights, mark what part of the *Castle-Wall* you see, for that part is in the true level with your eye, which point let be D; then, the Index still remaining fixed, move the Semicircle upwards or downwards, till (through the sights) you see the very top of the *Castle-Wall* at A, (the Semicircle still remaining immoveable) look what number of degrees and parts the Thrid cutteth, which degrees let be 55, which you must set down; lastly, measure the distance from G to B, which let be 200 Foot, to which add 5 Foot, the height of your Semicircle's Center from the ground C E, and it makes 205 Foot; by help of this distance, and the degrees before noted down, you may find the altitude of the *Castle-Wall*, as followeth.

#### *Example.*

Upon a piece of Velum or Paper, draw a line at length, as M N; towards one end whereof, as at B, erect a Perpendicular A B, representing the *Castle-Wall*; then from one of your *Scales* take with your Compasses 205 Foot, and set that distance upon your Paper or Velum, from B, the foot or bottom of the *Castle-Wall*, to C, so shall C upon your Paper represent the place on the ground where the *Semicircle* stood, and 5 Foot more being added (which is the height of your *Semicircle* from the ground) E C maketh 205 Foot, which taken from your Scale will reach from B to F.

This done, place the Center of your Protractor upon the Point F, and the Diameter thereof upon the line M N, then count 35 degrees (which is so much as 55 deg. which the thrid cut, wants of 90 deg.) upon the edge of the Protractor, and against it make a *mark* or *point* with your *protracting Pin*, through which point (or mark) and the point F, draw the line F A, cutting the line A B, representing the Castle-Wall in A; so shall A B be the height of the Wall, which being measured by the same Scale as B F 205 foot was taken from, will be found to be 143 foot; and so high is the Castle-Wall from the ground.

PROP.

## PROP. II.

*How to take the Height of an Object, which is not accessible at two Stations, by help of the* Semicircle.

SUppose A B to be a Castle Wall as before, and you cannot come nearer to the Wall than G, for that there is a Moat about the Wall so broad.

First, Place your Semicircle at G, the edge of the Moat or Trench, and directing the sights to A, the top of the Wall, you shall find the Thrid to cut 30 deg.

Secondly, Go backwards a competent distance of ground, in a right line, as to F, and there placing your *Semicircle* as before, direct the sights to A, where you shall find the Thrid to cut 55 deg.

Thirdly, Measure the distance between G and F, which let be 125 Foot; these two Observations being made at G and F, and the distance between them measured by the Chain, the altitude of the Wall may be easily attained in manner following.

*Example.*

First, Upon Paper, or the like, draw a line M N, upon which, towards one end thereof, as at F, place the Center of your Protractor; and because the Thrid there cut 55 deg. make a mark against 35 deg. of your Protractor (which is so much as 55 deg. wants of 90 deg.) and through this point, and the point F, draw a right line at length upwards.

Secondly, For that the distance between G and F (your two stations) was 125 Foot, take 125 out of some one of your scales, and set off that distance upon your paper from F to G.

Thirdly, Lay the Centre of your Protractor upon G, and the Diameter thereof upon the line M N; and because when you made Observation at G, the Thrid cut 30 deg. make a mark against 60 deg. of the Protractor, (which is so much as 30 deg. wants of 90 deg.) and through this mark, and the point G, draw a right line at length upwards, continuing it till it cut the former line drawn from F, which it will do in the point A.

Lastly, From the point A let fall a perpendicular upon the line M N, which will fall upon the point B, so is A B the height of the Castle-Wall, which if you take in your Compasses, and measure it upon the scale from whence you took your distance F G, you shall find it to contain 143 Foot, and so high is the Castle-Wall.

## PROP. III.

*A Fort or Castle being besieged, how the Besiegers shall know of what length to make Scaling-Ladders that shall reach from the edge of the Moat or Trench to the top of the Wall.*

LET A B be the Wall of a Fort or Castle, and that the Castle within were besieged, the Besiegers lying at F, and cannot come nearer

to

to the Wall than G, the edge of the Moat; wherefore ſtanding at G, make Obſervation with your Semicircle as you did before, and you ſhall find the Thrid to cut 30 deg. ——— Do the like at F, and you ſhall find the Thrid to cut 55 deg. and the diſtance between G and F meaſured will be found to be 125.—— Theſe two Obſervations being made, and the diſtance F G meaſured ( all which are the ſame as in the laſt *Prop.* ) you may protract or lay down the ſame upon Velum or Paper, in all reſpects as in the former *Prop.* and ſo meaſuring the line G A upon the ſame ſcale that G F was meaſured by, you ſhall find it to contain 166 Foot, and ſo long muſt Ladders be to ſcale the Walls of this Fort or Caſtle.

## PROP. IV.

*Standing upon a Wall or Tower of a known height, to find how far any Ship, Tree, &c. is from you.*

LET A be the top of a Tower or Caſtle ſtanding by the Sea-ſide, and let F be a Ship lying at Anchor, and you would know how far that Ship is off the Caſtle-Wall.

Standing upon the Tower-Wall at A, with your *Semicircle*, direct the ſights ( the Index lying upon the Diameter ) to F, the Thrid will cut 55 deg. Then, the Caſtle-Wall being 143 Foot high, by help of theſe two you may find the diſtance that the Ship at F is from the Caſtle-Wall B, in this manner :

Upon Paper or Parchment draw a line A B, repreſenting the Caſtle-Wall, and upon it by help of your ſcale, ſet the height thereof 143 Foot, from A to B, and upon the point B erect the Perpendicular B F.

Then placing the Center of your Protractor upon A, turn it about upon that Point, till 55 deg. ( which were the degrees cut by the Thrid) come to lye directly upon the line A B, then at 00 deg. (or the beginning of the Semicircle of the Protractor ) make a mark cloſe by the edge thereof, through which point and the point A, draw a line at length downwards, which line being drawn, will cut the line B F in the point F, ſo the diſtance B F being taken in your Compaſſes, and meaſured upon the ſame ſcale from whence A B (the height of the Wall) was taken, it will be found to contain 205 Foot, and ſo far is the Ship F from the Caſtle-Wall B.

## PROP. V.

*How to take an inacceſſible Diſtance at two Stations by the* Semicircle.

### FIG. II.

SUppoſe you were ſtanding at G, and that it were required of you to know how far diſtant the Tree of A is from you, between which and you there is the River D, ſo that you cannot come near A.

Firſt, Place your *Semicircle* at C, laying the Index on the Diameter thereof, and turn the Semicircle about till through the ſights you ſee the Tree at A, and there fixing the Semicircle, turn the Index about till you ſee the Mark ſet up at B, and there note what degrees the Index cutteth, which let be 110 deg. Secondly,

Secondly, Remove your Semicircle from C to B (ſetting up a Mark at G, where your *Semicircle* before ſtood) and laying the Index on the Diameter thereof, turn the *Semicircle* about till through the ſights thereof you ſee the Mark at C, where your Inſtrument before ſtood, and there, fixing the *Semicircle* turn the Index about till by the ſights you ſee the Tree at A, and there alſo note what degrees the Index cutteth, which let be 40 deg.

Thirdly, Meaſure the diſtance between C and B, which let be 120 Foot; by help of theſe three you ſhall find the diſtance of A from either C or B, as followeth.

*Example.*

Draw a line upon Paper, as A C, and laying the Centre of your Protractor upon C, and the Diameter thereof upon the line C A, with your protracting Pin make a mark againſt 110 deg. and through that point and the point C, draw a line C B; then from your Scale take 120 Foot, and ſet it upon the line C B, from C to B.

This done, lay the Center of your Protractor upon the point B, and the Diameter thereof upon the line C B, and make a mark againſt 40 deg. through which mark and the point B, draw the line B A, cutting the former line C A in the point A.

Laſtly, If you take in your Compaſſes the line C A, and meaſure it upon the Scale from which yon took B C 120 Foot, you will find it to contain 154 Foot and about half a Foot, and ſuch is the diſtance A C.

In like manner, if you meaſure A B by the ſame Scale, you ſhall find it to contain 224 Foot, and about half a Foot.

## PROP. VI.

*How to meaſure the Diſtance of ſeveral Places from you, as alſo of one from another, by meaſuring only of one* Diſtance, *and obſerving of* Angles *by the* Semicircle.

### FIG. III.

LET A, B, C, D, E, be ſeveral places, as Churches, in a Town or City, or the like, whoſe diſtance you require one from another.

Firſt, Make choice of two places, from either of which you may ſee all the places, whoſe diſtance you require, which places let be F and G, diſtant one from another 100 Foot.

Secondly, Place your Semicircle at F, and laying the Index on the Diameter, turn the Semicircle about till through the ſight you ſee your other place of ſtanding at G, and there fixing your Inſtrument, firſt direct your ſights to A, noting what degrees the Index cutteth; then to B, and note what degrees are there cut by the Index, doing the like at C, D, and E; all which degrees note down in a Book or Paper.

Then removing your Semicircle to G, and ſetting up a Mark at F, lay the Index on the Diameter thereof, and turn the Semicircle about till you ſee the place of your former ſtanding at F, and there fixing the *Semicircle*, make obſervation of every place, as you did at F: Firſt, directing the ſights to A, noting the degrees cut by the Index, likewiſe to B, C D, and E.

By these observations of Angles, made at either station F and G, and and the stationary distance, you may draw a perfect draught of all the places upon Paper or Velem, in their true position and scituation, in manner following :

*Example.*

First, Upon your Velem or Paper draw a line F G, containing 100 Foot of any Scale, which line shall represent the distance of your two stations.

Secondly, Place the Center of your Protractor upon F, and lay the Diameter thereof upon the line F G, and there keeping it steady, make a mark against those deg. which the Index cut upon the *Semicircle* when the sights were directed to A ; also make a mark against those deg. of the Protractor which the Index cut at B, and the like at C, D, and E.

Thirdly, Through the point F, and every one of those marks you made against the side of the Protractor, draw lines, as F A, F B, F C, above the line F G, and F D, F E, below the line.

Fourthly, Lay the Center of your Protractor upon the point G, and the Diameter thereof upon the line F G, and there keeping it fast make marks against the edge thereof, at those degrees the Index cut upon the Semicircle, when the sights were directed to A, B, C, D, and E ; and through those points and the point G, draw right lines G A, G B, G C, G D, and G E, cutting the former lines drawn from F, in the points A, B, C, D, and E ; which points will stand in the same position and scituation as the Churches or other places in the City or Town do ; and if you take in your Compasses the distance between any two of them, and measure that distance upon the same Scale that F G 100 was measured from, it will there shew you the distance of those two places.

## The Use of the Semicircle in Measuring of Land.

### PROP. I.

*To take the Plat of a* Field *by placing the* Semicircle *in any part thereof, from whence all the Angles of the* Field *may be seen.*

PLace your Semicircle upon its staff in some convenient place of the Field (whose Plat you would take) that from thence you may conveniently see all the Angles thereof, then setting the Semicircle level (by help of the Ball-socket) lay the Index upon the Diameter, and turn the Semicircle about till the Needle hang directly over the North and South Points of the Chard, and there fix the Semicircle, by help of the screw of the *plain Socket*, then doth the Instrument (the Diameter thereof) lye directly in the Meridian, and is fitted for your present use.

Your Instrument thus fixed, cause marks to be set up at every angle of the field (or rather let one go from angle to angle with a long staff having a white cloth or paper tied to the top thereof) and coming to your Instrument, the Diameter being next to you, and the Limb of the Semicircle from you, turn the Index about till through the sights thereof you espy the first of your marks (or man) which is on your right h

and,

hand, and when you have directly found your mark, let the Index rest, and see what degrees and parts of a degree of the Semicircle are cut thereby; which degrees and parts note dote down in a book or paper ruled as that which followeth.

In this nature must you deal with every angle round about the field, beginning at that which is next towards your left hand, and proceeding gradually from that towards the right hand, till you find that end of the Index which cut the degrees, falls off of the Instrument, (which will always be when you come past 180 degrees) then must you look through the other sights, and the Limb of the *Semicircle* will be next to you, and you must count your degrees from 180 towards 360; to which, before you come, you will have passed all your Angles.

When you have taken observation of all your Angles, you must, with your Chain, measure from the place where your Semicircle stands, to every Angle (beginning with the first, and so proceeding from the left towards the right hand) and note how many Chains and Links each line contains, which lengths must be set down in your book or paper, in a column by themselves against the degrees which the Index cut, when you made observation at that Angle, that is, the first length against the first degrees, and the second length against the second degrees; and in this order must you proceed till you have measured all your lengths.

### *The foregoing Precepts illustrated by Example.*

### FIG. IV.

LET *a, b, c, d, e, f, g,* be a field to be Surveyed. Place your *Semicircle* (it being a convenient place) at O, the diameter thereof, as also the Needle in the Box, hanging over the North and South Points in the Chard, then will they lye directly over the line N S in this figure; then fix your Instrument, and directing your sights to A (your first Angle) you shall find the Index to cut 12 *d* 15 *m.* which set down in your book or paper; then directing your sights to B, the Index cuts 37 *d.* at C, 94 *d.* 30 *m.* and the rest, as in the following Table, representing your book or paper in which you took your notes.

| | | *d.* | *m.* | | | C. | L. |
|---|---|---|---|---|---|---|---|
| The Index cut when directed to the mark, | A — | 12. | 15 | And the distance from O the place of the Semicircle, was | OA — | 10. | 35 |
| | B — | 37. | 0 | | OB — | 9. | 45 |
| | C — | 94. | 30 | | OC — | 10. | 30 |
| | D — | 169. | 15 | | OD — | 6. | 20 |
| | E — | 193. | 0 | | OE — | 8. | 93 |
| | F — | 270. | 30 | | OF — | 8. | 05 |
| | G — | 347. | 0 | | OG — | 5. | 20 |

Having gone through all your Angles, and noted them down in your book or paper, as is done in the foregoing Table, in the column having *d. m* at the top thereof (signifying Degrees and Minutes) you must then go to the measuring of your lines, where you shall find O A to contain 10 Chains 35 Links, O B 9 Chains 45 Links, and the rest as in the Table in that column which hath C. L. at the top thereof, C signifying Chains, and L Links.

When you have thus taken obſervation of all your Lines and Angles, and noted them down in a Book or Paper, you may at pleaſure draw the Plat of the Field upon Velum or Paper, by the Precepts which ſhall be delivered in the following Propoſition.

## PROP. II.

*How to lay down the Plat of the former Field upon Velum or Paper, by help of the former Obſervations of Lines and Angles.*

UPon a piece of Velum or ſheet of Paper, draw a line for the Meridian or North and South Line, repreſented by the line in the Figure by N S. In ſome convenient place of that line (as at O) aſſign a point, which point O upon your paper, repreſents or ſignifies the place in the field where your Semicircle ſtood when you made obſervation of your Angles.

Upon this point O place the Center of your Protractor, laying the Meridian Line or Diameter thereof juſt along the line N S, drawn upon the paper, and there hold it faſt. Then having recourſe to your Table of Angles, which you obſerved in the field, you find your firſt to be 12 deg, 15 min. wherefore, cloſe to the edge of your Protractor, and againſt 12 deg. 15 min. make a mark with your protracting Pin; and ſtill keeping your protractor in the ſame poſition unmoved, make a mark againſt 37 deg. your ſecond Angle, alſo againſt 94 deg. 30 min. your third Angle, and againſt 169 deg. 15 min. your fourth Angle.

Then becauſe your fifth Angle at E exceeds 180 deg. it being 193 deg. you muſt turn the *Semicircle* of your *Protractor* downwards, laying the Center thereof upon the point O, and the Diameter upon the line N S as before, and againſt 193 deg. make a mark with your protracting Pin, do the like againſt 270 deg. 30 min. your ſixth Angle, and againſt 347 deg. your laſt Angle.

Theſe points being marked upon your Paper, through every one of them, and the point O, draw obſcure lines, as O A, O B, O C, O D, O E, O F, and O G. ——Then having recourſe to your Table of Lines which you meaſured in the field, you find that the firſt line O A, contained 10 Chains 35 Links, wherefore from ſome Scale (according to the bigneſs you would have your *Plat*) take 10 C. 35 L. and ſet it upon your paper from O to A, this point A upon the paper ſhall repreſent the firſt Angle in the field A; your ſecond length being 9 C. 45 L. take that from your Scale, and ſet it upon your paper from O to B. Do thus with all the reſt of the lengths; and when you have found out and marked upon your paper the ſeveral points A, B, C, D, E, F, and G, if you draw lines from point to point, as from A to B, from B to C, from C to D, &c. you ſhall conſtitute the figure A B C D E F G, which ſhall be the exact *Plat* of your *Field* O. And thus may you take the *Plat* of any *Field*, where you may ſee all the Angles from any one place.

PROP.

## PROP. III.

*How to take the* Plat *of a* Field *or other piece of* Ground, *by placing the Semicircle in some one Angle thereof, from whence all the rest may be seen.*

YOur *Semicircle* being placed in the Angle where you intend to make your obſervation with the Index upon the Diameter thereof, and the Needle hanging over the Meridian Line in the Chard. It being thus fixed, direct your ſights to the firſt Angle towards your left hand, noting the degrees and minutes cut by the Index, and note them down in a book or paper, in all reſpects as you did thoſe in the former *Propoſition.*

Then meaſure with your Chain from that Angle where your *Semicircle* ſtandeth, to every one of the other Angles, noting the lengths of every of them, and write them alſo down in your book or paper, proceeding thus from the firſt line on your left hand, till you come round the field to that again.

*Example.*

FIG. V.

LET HKLMNOPQ be a piece of Ground to be meaſured in the manner here preſcribed: The *Semicircle* placed in the Angle Q, direct the ſights to H, where the Index cuts 15 deg. which note down, then direct the ſights to K, where the Index cuts 31 deg. 30 m. likewiſe to L, M, N, O, P, where the Index cut the degrees and parts, as in the Table following:

| | | d. | m. | | | C. | L. |
|---|---|---|---|---|---|---|---|
| The Index cut when directed to the Angle, | H — | 15. | 0 | And the diſtance from the Angle Q, as | QH — | 9. | 90 |
| | K — | 51. | 30 | | QK — | 10. | 25 |
| | L — | 87. | 14 | | QL — | 11. | 60 |
| | M — | 106. | 0 | | QM — | 12. | 30 |
| | N — | 168. | 15 | | QN — | 12. | 0 |
| | O — | 196. | 0 | | QO — | 10. | 85 |
| | P — | 250. | 0 | | QP — | 6. | 88 |

## PROP. IV.

*By the former Obſervations of Lines and Angles, to draw the Plat or Figure of the Field upon Velum or Paper.*

DRaw upon Velum or Paper a line N S, repreſenting the Meridian Line, upon which line aſſign a point as Q, which denotes the place where your *Semicircle* ſtood in the field.

Upon this point Q, lay the Center of your Protractor, and the Diameter thereof upon the line N S; and there holding it faſt, look in your Table what degrees the Index cut when you made obſervation at H, which were 15 degrees, make a mark againſt 15 degrees of your Protractor; likewiſe ſee by your Table what degrees the Index cut when

when you made obſervation at K, which were 31 deg. 30 min. make a mark againſt 31 deg. 30 min. of your Protractor; and in like manner do with every Angle, as at L, 87 deg. 15 min. at M, 106 deg. 0 min. at N, 168 deg 15 min. at O, 196 deg and at P, 250 deg. at all which numbers of degrees, make marks againſt the ſide of your Protractor.

Then removing your Protractor, draw right lines from the point Q through every one of thoſe marks, ſo ſhall you have upon your Velum or Paper the ſeveral Lines QH, QK, QL, QM, QN, QO, and QP.

Again repair to your former Table, where you ſhall find that the line QH, being meaſured by the Chain in the field, contained 9 Chains, 90 Links, take this diſtance from any of your Scales, and ſet it upon the line QH, from Q to H; and ſo have you the point H upon the paper.

In like manner, take 10 Chains 25 Links from your Scale, and ſet it from Q to K, ſo have you the point K upon paper. And in this manner deal with all the numbers of Chains and Links in your Table, and they will give you the points L, M, N, O, P, upon your Velum or Paper.

Laſtly, If you draw the lines QH, QK, QL, QM, QN, QO, QP; you ſhall thereby conſtitute the true Symetry or Proportion of the field you meaſured, the ſeveral Angles whereof are H, K, L, M, N, O, P, and Q.

## PROP. V.

*How you may by the Semicircle take the true Plat of any large piece of Ground, as* Park, Wood, Marſh, *or other ſpacious Incloſures, by going round about the ſame.*

IN going round about a field (or other ground) to ſurvey, there are two ways, but both effected by the ſame artifice; for in going about a field, you may either go about it on the inſide of the field, or on the outſide thereof; and ſometimes you ſhall be conſtrained to go partly within and partly without; and if you go without the field, you may (if you will) take the quantity of the Angles within; and if you go on the inſide, you may take the quantity of the Angles without. Of both which ways I ſhall give Examples.

### I. *By going about the Field within the ſame.*

Let ABCDEF be a Field to be meaſured by going about the ſame on the outſide.

### FIG. VI.

Firſt, Begin at any Angle thereof, as A, and there place your Semicircle, laying the Index upon the Diameter, and turning it about, direct the ſights to B, there fix the Semicircle, and turn the Index about, till through the ſights you ſee the Angle at F, and there note what deg. the Index cutteth, which you will find to be 300, for the quantity of the exterior Angle FAB without the field, or 60 deg. for the quantity of the interior Angle within the field; but (as I ſaid before) going with-

without the Field I make uſe of the exterior or outward Angles: Then meaſure the ſide F A, which you ſhall find to be 10 Chains 25 Links, and the ſide A B 7 Chains 50 Links, theſe diſtances with the quantity of the Angle note down in a Book or Paper, as you ſee in the following Table.

Secondly, Remove your Semicircle to B, and laying the Index upon the Diameter, turn the Inſtrument about, till through the ſights you ſee the place where your Semicircle laſt ſtood at A, and then fixing it, turn the Index about, till by the ſights you ſee the Angle C, and there note the *degrees* which the Index cutteth, which here are 145 *degrees*, and the diſtance B C meaſured is 7 Chains 10 Links; note both the *degrees* and diſtance down as before.

Thirdly, Carry your Semicircle to C, and placing the Index on the Diameter, look back to B, and there fix the Inſtrument, then turn the Index about till you ſee the Angle at D, where the Index cutteth 270 *degrees*, and the diſtance C D is 5 Chains 85 Links.

Fourthly, Remove the Semicircle to D, and the Index on the Diameter, look back to C, then fix the Semicircle and turn the Index about, till by the ſights you ſee the Angle at E, the Index cutting 263 *degrees*, and the meaſured diſtance D E being 7 Chains, note theſe down in your book or paper.

Fifthly, Place the Semicircle at E, and the Index lying on the Diameter, look back through the ſights to D, then fixing the Inſtrument there, turn the Index about till by the ſights you ſee the Angle F, the Index cutteth 220 *degrees*; and the meaſured diſtance E F being 10 Chains 70 Links, both which you muſt note down. And,

Sixthly, Carry the Semicircle to F, and the Index lying on the Diameter, look back to E, and then fix the Inſtrument, then turn the Index about till by the ſights you ſee your firſt Angle at A, the Index then cutting 210 *degrees*; theſe being noted down will ſtand as in this Table.

| | | *d.* | *m.* | C. | L. | |
|---|---|---|---|---|---|---|
| Angles. | A | 300 | 0 | 10 | 25 | Sides. |
| | B | 145 | 0 | 7 | 50 | |
| | C | 270 | 0 | 7 | 10 | |
| | D | 263 | 0 | 5 | 85 | |
| | E | 210 | 0 | 7 | 00 | |
| | F | 210 | 0 | 10 | 70 | |

Theſe Obſervations of Sides and Angles being made in the Field, and noted down as in the foregoing Table, a Plat thereof may be drawn upon Velum or Paper by help of the following Directions.

## PROP. VI.

*How to draw a true* Plat *of the Field before meaſured, by help of the Table of Sides and Angles.*

UPON your Velum or Paper draw a Line A B, containing 7 Chains 50 Links of any Scale, and upon the end A place the Centre of the *Protractor*, laying the Diameter upon the line A B, then the exterior Angle A being 300 *degrees*, make a mark againſt 300, and through

through that point and the point A, draw a line downwards as A F, containing 10 Chains 25 Links.

Secondly, Place the Centre of the *Protector* upon B, and the Diameter upon A B, and againſt 145 *degrees* (the Angle at B) make a mark, and through that mark and B draw the line B C, containing 7 Chains 10 Links.

Thirdly, Lay the Centre of the *Protractor* upon C, and the Diameter upon B C, and againſt 270 *deg.* make a mark, through which, and C, draw the line C D, containing 5 Chains 85 Links.

Fourthly, Lay the Centre of the *Protractor* upon D, and the Diameter upon C D, making a mark againſt 263 *deg.* through which, and the point D, draw the line DE, to contain 7 Chains.

Laſtly, Lay the Centre of the *Protractor* upon E, and its Diameter upon D E, and againſt 220 *deg.* make a mark, through which, and the point E, draw a right line E F, which will cut your line A F in F; ſo have you upon you Velum or Paper, the true figure of your Field, A B C D E F.

*In all the Work of theſe two laſt* Propoſitions, *we have wrought by the exterior or outward Angles: If any have a deſire to work by the interior or inward Angles, it is but taking the exterior Angle from* 360 degrees, *and the interior Angle will remain. So the Angle at A being* 300 degrees, *that taken from* 360 degrees, *leaves* 60 degrees *for the interior Angle at A. So B being* 145 degrees, *that taken from* 360, *leaves* 215 *for the interior Angle.*

### II. *By going about the* Wood *or* Park *on the* Outſide *thereof.*

THE foregoing way, where the Hedges are ſtreight, and not many; and the Ground clear of *Wood*, *Pools*, *Quags*, and ſuch like, is ſufficient to perform the Works there intended: But if the *Wood* be overgrown, ſo that you cannot ſee from Angle to Angle, nor meaſure along by the Hedge-ſide, then make uſe of the way hereafter preſcribed.

FIG. VIII.

Let A B C D E F G H I K L M N O, be a *Wood* to be *meaſured* and *Plotted*, and it is ſo overgrown with Wood that ye cannot by any means come within the ſame to meaſure any *Sides*, or ſee to take any *Angles*; wherefore you muſt go on the outſide thereof: And having made choice of a place, as at P, where to begin your Survey, here ſet up a viſible mark, then ſtanding at P, look along the Wood's ſide towards Q, where ſet up another viſible Mark: And at Q, look towards R, where ſet up another viſible Mark as at R: From which looking along the Wood's ſide (as near the ſide as you can) ſet up another Mark as S, from whence you may ſee your firſt Mark at P: and by this means you have encompaſſed the whole *Wood* within the Quadrilateral Figure P Q R S: And now to begin your Inſtrumental Work:

1. Set up your *Semicircle* at P, laying the Index upon the Diameter thereof, and turn the whole Inſtrument about, till through the Sights you

you ſee the *Mark* ſet up at Q, and then fix the Inſtrument, and turn the Index about till through the Sights you ſee the laſt Mark at S: where the Index will cut 89 deg. 00 m. Which ſet down in the firſt Column of a *Field-Book*, or Paper, ruled like this in the *Margin*: Then at the beginning of your Meaſure from P towards Q, you find that the corner of the Wood at A is diſtant from P, 1 Chain and 80 L ſet down 1 C. 80 L. in the next Column; and in the third Column ſay, from P to A: —— Then meaſuring along the *Chain-Line* from P towards Q, I find that from Q to a is 3 C. 55 L. which I ſet down in the firſt Column; and becauſe *a* is diſtant from the Angle of the Wood at B 90 L. I ſet down 0 C. 90 L. and in the third Column, from *a* to B— Then meaſuring on till I come to *b*, 4 Ch. 60 Li. I find the Chain to touch the very corner of the Wood at C, wherefore, I write down 4 C. 60 L. in the firſt Column; *Touch*. in the ſecond Column, and at C, in the third Column: And in this manner I proceed in *Meaſuring* and *ſetting down* (as in the Margin) till I come to the ſecond Mark at Q: Then

| d. m. | | |
|---|---|---|
| 89 00 | C. L. | From |
| 0 00 | 1 80 | P to A |
| 3 55 | 0 90 | a B |
| 4 60 | touch | at C |
| 8 50 | 1 40 | c D |
| 11 15 | 0 50 | d E |
| 12 70 | 0 80 | e F |
| 15 00 | touch | at G |
| 18 80 | 0 0 | at Q |
| 87 30 | C. L. | From |
| 0 00 | 0 90 | Q to G |
| 3 00 | touch | at H |
| 6 35 | 0 60 | h I |
| 6 90 | 0 00 | at R |
| 91 00 | C. L. | From |
| 0 60 | 0 40 | k to I |
| 2 75 | touch | at K |
| 5 45 | 0 65 | m L |
| 8 40 | 0 70 | n M |
| 11 90 | touch | at N |
| 14 90 | 1 20 | p O |
| 15 65 | 0 0 | at S |
| 92 30 | C. L. | From |
| 0 00 | 0 0 | at S |
| 1 10 | 0 85 | q to O |
| 4 70 | touch | at A |
| 6 50 | 0 0 | at P |

2. Set up your *Semicircle* at Q, the Index upon the Diameter hereof; and turn the Inſtrument about till through the Sights you ſee your firſt Mark at P, and then faſten it: Then turn the Index about to R, where you ſhall find it to cut 87 Deg. 30 m. which ſet down in the firſt Column of your Book: And meaſuring from Q towards R, you find, that at 3 Chains end, the Chain touches the Corner of the Wood at H, wherefore, write down 3 Chains in the firſt Column, *Touch* in the ſecond Column, and at H in the third Column: Then meaſuring on towards R, till I come to *h*, 6 Ch. 35 L. I find that the Angle at *h*, is diſtant from I, 60 Links: wherefore, I ſet down 6 C. 35 L. in the firſt Column, 60 L. in the ſecond, and, from *h* to I in the third Column: And laſtly, 6 C. 90 L. at R.

3. In like manner ſet up your Inſtrument at R, and at S, meaſuring and ſetting down as before, and as you ſee done; And you ſhall find all the Sides and Angles to be ſuch as they are noted to be in the figure of the Field-book in the Margin: From whence, by what hath been already ſaid, and the ſight of the *Figure* (which will give more light to the Work than a whole *Chapter* of Directions) you may draw a true *Plot* of the *Wood* upon *Paper* or *Parchment*.

And for the caſting up of the *Content* thereof the directions formerly given, in *meaſuring* by the *Chain* only : And thoſe which follow in the next *Propoſition* will ſufficiently inform you.

But, by way of *Advertiſement*, In this *Example* where you went on the outſide of the *Wood*, you muſt firſt find the *Content* of the whole *Quadrilateral Figure* P Q R S, and then of the ſeveral ſmall *Triangles* and *Trapezias* made without the Wood, as the *Trapezia*, P a B r, and the reſt : Which being deducted from the Content of the whole *Quadrilateral* P Q R S, will leave the *Content* of the whole *Wood* included therein.

## PROP. VII.

*The Plat of a Field being laid upon Paper, and the Scale by which it was laid down known, to find how much the ſaid Field containeth in Acres, Roods and Perches.*

THere are ſeveral ways to effect this ; but I ſhall here deliver only one, which ſhall be general, and that which by all (or moſt) Surveyors is practiſed.

Every irregular Plat or Figure, before the quantity or content of it can be found, muſt firſt be reduced into ſuch Regular Figures, for the menſuration whereof there are certain Rules : The moſt meet and convenient Figures into which Irregular Plats may be reduced, are Triangles and Quadrilaterals, called Trapezias, which is done by drawing of lines from Angle to Angle croſs the Plat. And here note, That of how many ſides ſoever your Plat conſiſteth, into ſo many Triangles, wanting two, will the Plat be reduced, and no leſs, as the Figure VII. denotes, where the Plat conſiſteth of 7 Sides, and it is reduced into 5 Triangles.

*The manner of reducing the Plat into Triangles.*

### FIG. VII.

LET the Figure A B C D E F G be a *Plat* which contains ſeven ſides ; to reduce which into Quadrilaterals and Triangles, do thus :

Firſt, Draw the line B F, ſo is part of the *Plat* reduced into the Quadrilateral A B F G.

Secondly, Draw the line F D, ſo is another part of the *Plat* reduced into the Trapezia B C D F ; and the other part of the *Plat* is comprehended in the Triangle F D E.

Thus the whole *Plat* being reduced, contains two Trapezias, *viz.* K and L, and the Triangle M, in number five, (for every Trapezia contains two Triangles) which are leſs by two than the number of ſides.

To

*To cast up the Quantity or Content of the* Plat.

First begin with the Triangle M, whose base, F B, is 13. 75. that is, 13 Chains 75 Links, and his Perpendicular E Q, 7 Chains 12 Links.

Now the Quantity, *Area*, or Content of every Triangle, is found, By multiplying the length of the base by half the length of the perpendicular.

So here the base 13. 75. and the perpendicular 7. 12. the half whereof is 3. 56. if you multiply 13. 75. by 3. 56. (as if they were whole Numbers, tho in reality the 75 and 56 are Fractions) the Product will be 4. 8 9 5 0 0, and that is the Quantity of the Triangle F D E.

$$\begin{array}{r} 13.75 \\ 3.56 \\ \hline 8250 \\ 6875\phantom{0} \\ 4125\phantom{00} \\ \hline 4.89500 \end{array}$$

Secondly, For the Trapezia or Quadrilateral L, in which Trapezia you may see that the line C F is a common base to the two Triangles B F C, and C D F, for the perpendiculars B P, and D O, of both Triangles, fall upon it.

Now the Quantity of any Trapezia is found, *By multiplying the common base* (here F C) *by half the Sum of the two Perpendiculars which fall upon it* (here B P, and D O.)

So in this Trapezia, the common base C F, is 14 C. 90 L. and the sum of the two Perpendiculars B P, and D O, is 13 Chains 80 Links, the half whereof is 6. 90. If you multiply 14. 90. by 6. 90. the Product will be 10. 28100.

$$\begin{array}{r} 14.90 \\ 6.90 \\ \hline 134100 \\ 8940\phantom{0} \\ \hline 10.28100 \end{array}$$

Thirdly, For the Trapezia K, multiply 12. 66. (the length of the base B G) by 4. 55. half the sum of the two perpendiculars A H and F R, the Product of that Multiplication will be 5.76030, which is the Quantity, Area, or Content of the Trapezia K.

$$\begin{array}{r} 12.66 \\ \hline 4.55 \\ 6330 \\ 6330\phantom{0} \\ 5064\phantom{00} \\ \hline 5.76030 \end{array}$$

Thus have you the Content of the two Trapezias and the Triangle. Now,

*To find the Quantity of the whole Field, in* Acres, Roods, *and* Perches.

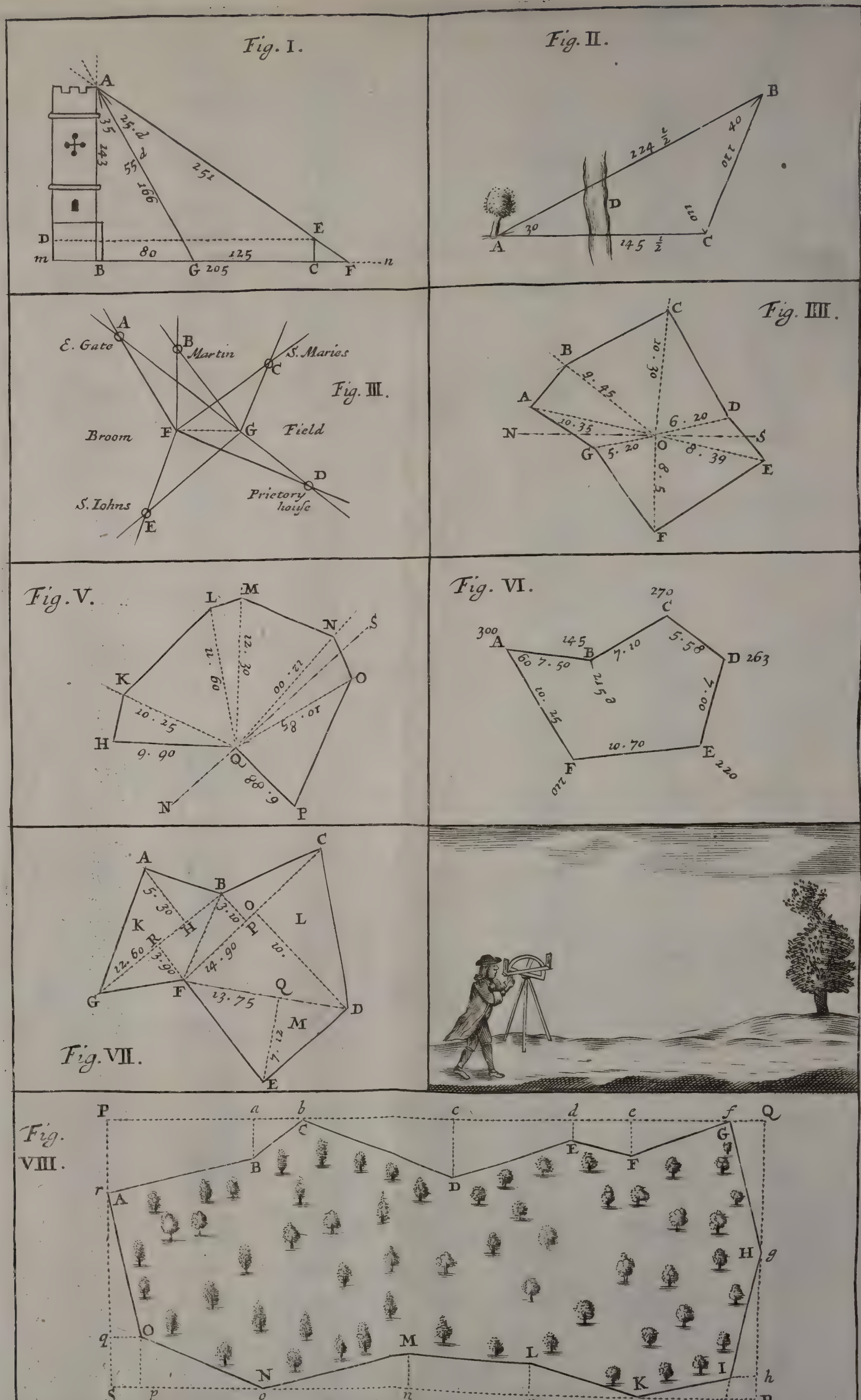
Add the Products of the several Multiplications together, the Sum of them is the whole Quantity. So

| | | | |
|---|---|---|---|
| The | Triangle M | containing | 4. 89500 |
| | Trapezia K | | 5. 76030 |
| | Trapezia L | | 10. 28100 |
| | | Their Sum is | 20. 93630 |

Which is 20 compleat or entire Acres, and $\frac{93630}{100000}$ parts of an Acre; and to know how much that is, multiply 93630 by 4 (becauſe 4 Roods make an Acre) the Product is 3 compleat, and $\frac{74520}{100000}$ parts of a Rood; and to know how much that is, multiply 74520 by 40 (becauſe 40 Perches are contained in one Rood) the Product will be 29.80800, which is 29 compleat Perches, and $\frac{80800}{100000}$ parts of a Perch, which is inconſiderable, for 160 whole Perches make but one Acre.

$$\begin{array}{r} 93630 \\ 4 \\ \hline 3.74520 \end{array} \qquad \begin{array}{r} 74520 \\ 40 \\ \hline 29.80800 \end{array}$$

Thus have you the Area, Quantity, or Content of this Field caſt up, and you find it to contain 20 Acres, 3 Roods, and 29 Perches. And in this manner may you caſt up the quantity of any Irregular Plat whatſoever, remembring that in all your Multiplications you cut off 5 figures towards your right hand with a prick of your Pen, as in this Work I have done all along.




Place this against Page 68 of Geometricall Recreations; to fold out.

# Mechanical RECREATIONS.

## CHAP. I.

### *Of Engines, by help of which we may Raise a very great Weight, with small Strength.*

THE invention of all these Engines depend upon one Sole Principle; which is,

That, *The same Force that can lift up a Weight* (for Example of 100 Pounds) *to the height of one Foot; can lift up one of* 200 *Pounds, to the height of half a Foot: Or one of* 400 *Pounds to the height of a fourth part of a Foot*; And so of the Rest, be there never so much applyed to it.

And this *Principle* cannot be denied, if we consider that the *Effect* ought to be proportioned to the *Action* that is necessary for the Production of it: So that, if it be necessary to employ an *Action* by which we may raise a *Weight* of 100 Pounds, to the height of *two Foot*; for to raise one such to the height of *one Foot* only, this same ought to weigh 200 Pounds: For, it's the same thing to raise 100 Pounds to the height of *one Foot*; and again yet another 100 Pounds to the height of *one Foot*, as to raise one of 200 Pounds to the height of *one Foot*, and the same also, as to raise 100 Pounds to the height of *two Feet*.

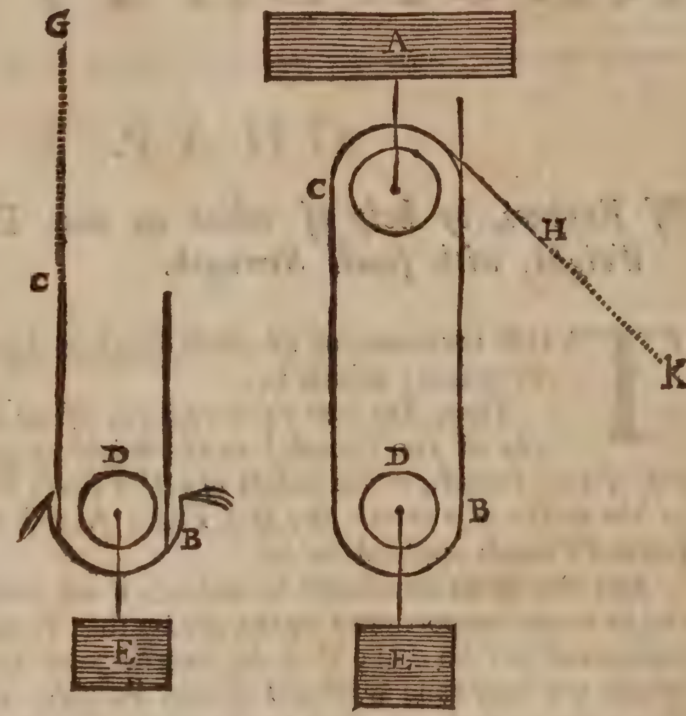
Now the *Engines* which serve to make this *Application* of a *Force* which acteth at a *Great Space* upon a *Weight* which it causeth to be raised by a Lesser, are

*Trochela*, the Pulley.
The inclined Plain.
*Cuneus*, the Wedge.
*Axis in Peritrochio*, the Crane, Capsten, or Wheel.
*Cochlea*, the Screw.
*Vectis*, the Leaver.

And some others: For, if we will not apply, or compare *them* one to another, we cannot well number *more*: And if we will apply *them*; we need not instance in so *many*.

## CHAP. II.

### *Of the Pulley* PROCLEA.




LET A, B, C, be a Cord put about the Pulley D, to which let the Weight E be fastned; and first, supposing that two Men sustain, or pull up equally each of them, one of the Ends of the said Cord: It is manifest, that if the Weight weigheth 200 Pounds, each of those shall employ but the half thereof, that is to say, the Force that is requisite for sustaining, or raising of 100 Pounds, for each of them shall bear but the half of it. Afterwards, let us suppose that A, one of the Ends of this Cord, being made fast to some Nail, the other C be again sustained by a Man; and it is manifest, that this Man in C needs not (no more than before) for the sustaining the Weight E, more Force than is requisite for the sustaining of 100 Pounds; because the Nail at A, doth the same Office as the Man which we supposed there before. In fine, let us suppose that this Man in C do put the Cord to make the Weight E to Rise; and it is manifest, that if he there employeth the Force which is requisite for the Raising of an hundred pound to the height of two Foot, he shall Raise this Weight E of 200 Pounds to the height of one Foot; for the Cord A B C being doubled, as it is, it must be pulled two Foot by the end C, to make the Weight E rise as much, as if two Men did draw it, the one by the end A, and the other by the end C, each of them the length of one Foot only.

There is always one thing that hinders the exactness of the Calculation, that is the ponderosity of the Cord or Pulley, and the difficulty that we meet with in making the Cord to slip, and in bearing it: But

But this is very ſmall in compariſon of that which raiſeth it, and cannot be eſtimated ſave within a ſmall matter.

Moreover, it is neceſſary to obſerve, that it is nothing but the redoubling of the Cord, and not the Pulley, that cauſeth this Force; for if we faſten yet another Pulley towards A, about which we paſs the Cord A B C H, there will be required no leſs Force to draw H towards K, and ſo to lift up the Weight E, than there was before to draw C towards G. But if to theſe two Pulleys we add yet another towards D, to which we faſten the Weight, and in which we make the Cord to run or ſlip, juſt as we did in the firſt, then we ſhall need no more force to lift up this Weight of 200 Pounds, than to lift up 50 pounds without the Pulley; becauſe that in drawing four Feet of Cord we lift it up but one Foot. And ſo in multiplying of the Pulleys, one may raiſe the greateſt Weights with the leaſt Forces. It is requiſite alſo to obſerve, that a little more Force is always neceſſary for the raiſing of a Weight, than for the ſuſtaining of it; which is the Reaſon why I have ſpoken here diſtinctly of the one and of the other.

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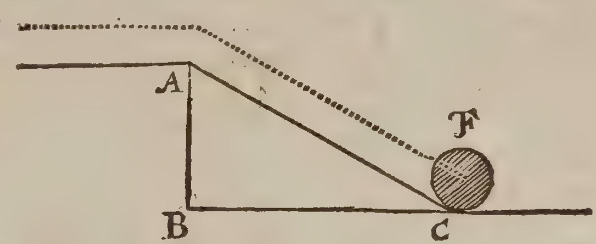
## CHAP. III.

### *Of the Inclined* PLANE.




IF not having more force than ſufficeth to raiſe an hundred Pounds, one would nevertheleſs raiſe this Body F, that weigheth 200 Pounds, to the height of the Line B A, there needs no more, but to draw or rowl it along the Inclined Plane C A, which I ſuppoſe to be twice as long as the Line A B, for by this means, for to make it arrive at the Point A, we muſt there employ the Force that is neceſſary for the raiſing 100 Pounds twice as high, and the more enclin'd this Plane ſhall be made, ſo much the leſs force ſhall need to raiſe the Weight F: But there is to be rebated from this Calculation, the difficulty there is in moving the Body F, along the Plane A C, if that Plane were laid down upon the Line B C, all the parts of which I ſuppoſe to be equidiſtant from the Center of the Earth.

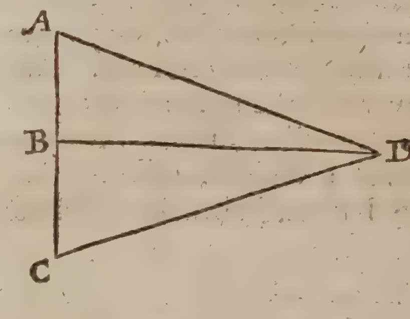
It is true, that this impediment being ſo much leſs as the Plane is more united, more hard, more even, and more polite, it cannot be likewiſe eſtimated but by gueſs, and it is not very conſiderable.

We need not neither much to regard that the Line B C, being a part of Circle that hath the ſame Center with the Earth, the Plane A C ought to be (though but very little) Curved, and to have the Figure of part of a Spiral, deſcribed between two Circles, which like-

wiſe have for their Center that of the Earth; for that it is not any way ſenſible.

# CHAP. IV.

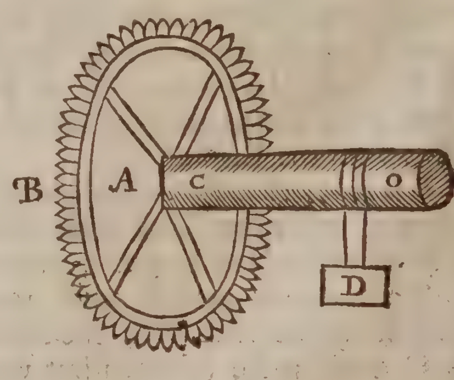
## *Of the* WEDGE *Cuneus.*




THE force of the Wedge A B C D, is eaſily underſtood after that which hath been ſpoken above of the enclined Plane, for the force wherewith we ſtrike downwards, acts as if it were to make it move according to the Line B D; and the Wood, or other thing and body that it cleaveth, openeth not, or the Weight that it raiſeth doth not raiſe, ſave only according to the Line A C; inſomuch, that the force wherewith one driveth or ſtriketh this Wedge, ought to have the ſame proportion to the reſiſtance of this Wood or Weight, that A C hath to A B: Or elſe again, to be exact, it would be convenient that B D were a part of a Circle, and A D and C D two portions of Spirals that had the ſame Center with the Earth, and that the Wedge were of a matter ſo perfectly hard and polite, and of ſo ſmall Weight, as that any little force would ſuffice to move it.

# CHAP. V.

## *Of the* CRANE, CAPSTEN, *or* WHEEL, *Axis in Peritrochio.*

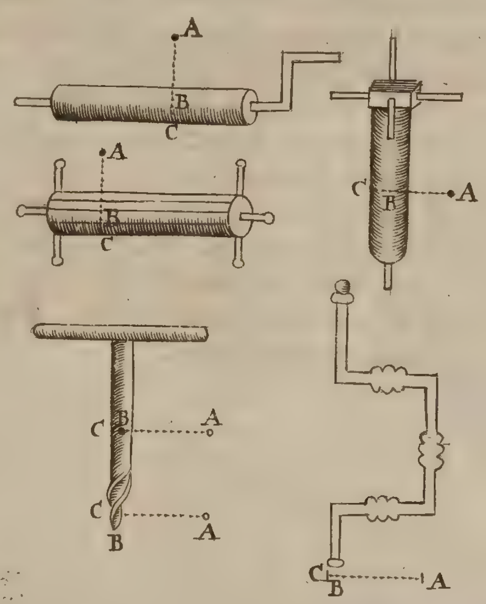



WE ſee alſo very eaſily, that the force wherewith the Wheel A or Cogg B is turned, which make the Axis or Cylinder C to move, about which a Cord is Rolled, to which the Weight D, which we would raiſe is faſtned, ought to have the ſame proportion to the ſaid Weight, as the circumference of the Cylinder hath to the Circumference of a Circle which that

force

force describeth, or that the Diameter of the one hath to the Diameter of the other, for that the Circumferences have the same proportions as the Diameters: Insomuch, as the Cylinder C having no more but one Foot in Diameter, if the Wheel A B be six Feet in its Diameter, and the Weight D do weigh 600 pounds, it shall suffice that the force in B shall be capable to raise an 100 Pounds, and so of others. One may also, instead of the Cord that rolleth about the Cylinder C, place there a small Wheel with Teeth or Cogs, that may turn another greater, and by that means multiply the Power of the force as much as one shall please, without having any thing to deduct of the same, save only the difficulty of moving the Machine, as in the others.

Unto this Faculty of the *Wheel*, may be referred the Force of all those *Engines* which consist of *Wheels* with Teeth in them: And from hence also may be discerned the Reason why sundry *Instruments* in common use are framed, as *Hand-Mills*, the *Piercer*, the *Gimlet*, &c. as in the Figure. All which are but several kinds, of this fourth *Faculty* the *Wheel*; in all which *Instruments*, the Points A B C do represent the Places of the *Power*, the *Fulsiment* and the *Weight*. The *Power* being in the same proportion unto the *Weight* as B C is unto B A.




# CHAP VI.

## *Of the* SCREW *Cochlea.*

WHen once the force of the Capsten, and of the inclined Plane is understood, that of the Screw is easie to be computed, for it is composed only of a Plane much inclined, which windeth about the Cylinder; and if this Plane be in such manner inclined, as that the Cylinder ought to make *v. gr.* ten turns, to advance forwards the length of a Foot in a Screw, and that the

the bigneſs of the Circumference of the Circle which the force that turneth it about doth deſcribe be of ten Feet; foraſmuch,as ten times ten are one hundred, one Man alone ſhall be able to preſs as ſtrongly with this Inſtrument, or Screw, as one hundred without it, provided always, that we rebate the force that is required to the turning of it.

Now I ſpeak here of preſſing rather than of Raiſing, or removing, in regard that it is about this moſt commonly that the Screw is employed: but when we would make uſe of it for the raiſing of Weights, inſtead of making it to advance into a Female Screw, we joyn or apply unto it a Wheel of many Cogs, in ſuch ſort made, that if *v. gr.* this Wheel have thirty Cogs, whilſt the Screw maketh one entire turn, it ſhall not cauſe the Wheel to make more than the thirtieth part of a turn, and if the Weight be faſtned to a Cord, that Rolling about the Axis of this Wheel ſhall raiſe it but one Foot in the time that the Wheel makes one entire Revolution, and that the greatneſs of the Circumference of the Circle that is deſcribed by the force that turneth the Screw about be alſo of ten Feet, by Reaſon that 10 times 30 makes 300, one ſingle *Man* ſhall be able to raiſe a Weight of that bigneſs with this Inſtrument, which is called the *Perpetual Screw*, as would require 300 Men without it.

Provided, as before, that we thence deduct the difficulty that we meet with in turning of it, which is not properly cauſed by the Ponderoſity of the Weight, but by the force or matter of the Inſtrument, which difficulty is more ſenſible in it, then in thoſe aforegoing, foraſmuch as it hath greater Force.

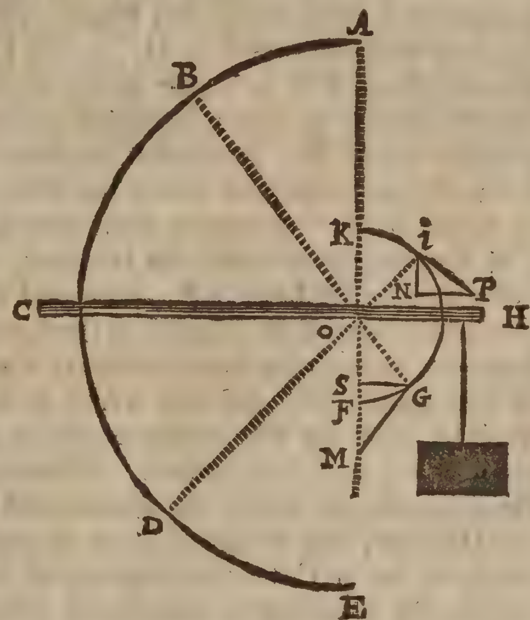
CHAP.

# CHAP. VII.

## Of the LEAVER *Vectis.*

I Have deferred to ſpeak of the *Leaver* until the laſt, in regard, that it is of all Engines for raiſing of Weights, the moſt difficult to be explained.

Let us ſuppoſe that C H is a Leaver, in ſuch manner ſupported, at the Point O, (by means of an Iron Pin that paſſeth through it acroſs, or otherwiſe) that it may turn about upon this Point O, its Part C deſcribing the Semicircle A B C D E, and its Part H the Semicircle F G H I K, and that the Weight which we would raiſe by help of it were in H, and the force in C, the Line C O being ſuppoſed Triple of O H. Then let us conſider, that in the time whilſt the Force that moveth this Leaver, deſcribeth the whole Semicircle A B C D E,




although that the Weight deſcribeth likewiſe the Semicircle F G H I K, yet it is not raiſed to the length of this Curved Line F G H I K, but only to that of the Line F O K; inſomuch, that the proportion that the Force which moveth this Weight ought to have to its Ponderoſity, ought not to be meaſured by that which is between the two Diameters of theſe Circles, or between the two Circumferences, as it hath been ſaid before of the Wheel, but rather by that which is between the Circumference of the Greater, and the Diameter of the Leſſer. Furthermore, let us conſider, that there is a neceſſity that this Force needeth not be ſo great, at ſuch time as it is near to A, or near to E, for the turning of the Leaver, as then when it is near to B or to D, nor ſo great when it is near to B or D, as then when it is near to C; of which the Reaſon is, that the Weights there do mount leſs; as it is eaſie to underſtand, if having ſuppoſed that the Line C O H is parallel to the Horizon, and that A O F cutteth it at Right Angles, we take the Point G equidiſtant from the Points F and H, and the Point B equidiſtant from A and C; and that having drawn G S Perpendicular to F O, we obſerve that the Line F S (which ſheweth how

how much the Weight mounteth in the time that the Force operates along the Line A B) is much Lesser than the Line S O, which sheweth how much it mounteth in the time that the Force operates along the Line B C.

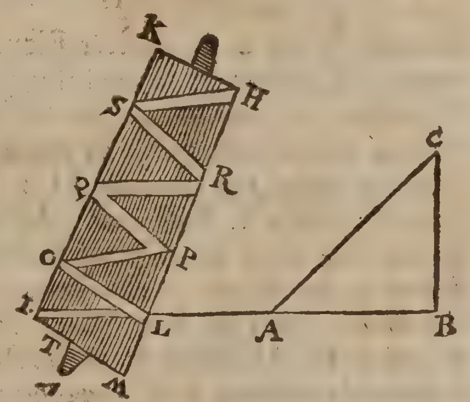
And to measure exactly what his Force ought to be in each Point of the Curved Line A B C D E, it is requisite to know that it operates there, just in the same manner, as if it drew the Weight along a Plain Circularly Inclined; and that the Inclination of each of the Points of this Circular Plain were to be measured by that of the Right Line, that toucheth the Circle in this Point. As for Example; when the Force is at the Point B, for to find the proportion that it ought to have with the Ponderosity of the Weight which is at that time at the Point G, it is necessary to draw the Contingent Line G M, and to account that the Ponderosity of the Weight is to the Force which is required to draw it along this Plain, and consequently to raise it, according to the Circle F G H, as the Line G M is to S M. Again, forasmuch as B O is Triple to O G, the Force in B, needs to be to the Weight in G, but as the third part of the Line S M, is unto the whole Line G M. In the self same manner, when the Force is at the Point D, to know how much the Weight Weigheth at I, it is necessary to draw the Contingent Line betwixt I and P, and the Right Line I N Perpendicular upon the Horizon, and from the Point P, taken at discretion in the Line I P, provided that it be below the Point I, you must draw P N parallel to the same Horizon, to the end you may have the proportion that is betwixt the Line I P, and the third part of the Line I N, for that which is betwixt the Ponderosity of the Weight, and the Force that ought to be at the Point D for the moving of it; and so of others. Where, nevertheless, you must except the Point H, at which the Contingent Line being Perpendicular upon the Horizon, the Weight can be no other than Triple the Force which ought to be in C for the moving of it: In the Points F and K, at which the Contingent Line being parallel unto the Horizon it self; the least Force that one can Assign, is sufficient to move the Weight. Moreover, that you may be perfectly exact, you must observe that the Lines S M and P M ought to be parts of a Circle, that have for their Center that of the Earth; and G M and I P, parts of Spirals drawn between two such Circles: And lastly, that the Right Lines S M and I N, both tending towards the Center of the Earth, are not exactly Parallels: And furthermore, that the Point H, where I suppose the Contingent Line to be Perpendicular unto the Horizon, ought to be some small matter nearer to the Point F than to K, at the which F and K the Contingent Lines are Parallels unto the said Horizon.

CHAP.

# CHAP. VIII.

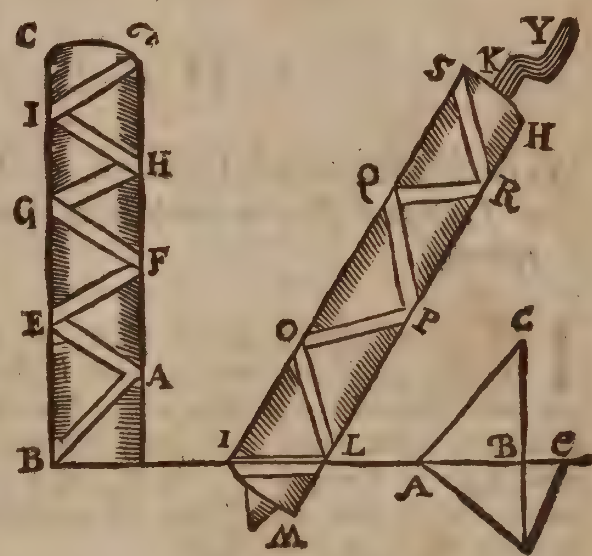
## *Of* Archimedes *his* Cochlea, *or* Water Screw, *and how a Perpetual Motion hath been attempted to be performed thereby.*

I Do not think it fit in this place, to paſs over with ſilence, the Invention of *Archimedes* to raiſe *Water* with the *Screw*, which is not only *Marvelous* but *Miraculous*: For we ſhall find, that the *Water* aſcendeth in the *Screw* continually deſcending: And in a given *time*, with a given *Force*, doth raiſe an unſpeakable quantity thereof. But before we proceed any farther, let us declare the uſe of the *Screw* in making *Water* to *Riſe*: And in the Figure let us conſider the Line I L O P Q R S H, being an hollow Pipe of Metal, wrapped or turned about the Columb M I K H, or a hollow Channel, cut in the Columb of Wood, and covered with thin Plate of Braſs or Latten, through which the Water may run. If we ſhall put the end I into the Water, making the Screw to ſtand Leaning, ſo as the Point L may be lower than the firſt I, (as the Diagram ſheweth) and ſhall turn it round about on the two Axes T and V, the Water ſhall run thorough the Pipe or Channel, till, that in the end, it ſhall diſcharge forth at the Mouth H. Now I ſay, that the water, in its conveyance from the Point I, to the point H, doth go all the way deſcending, although the Point H be higher than the Point I: Which that it is ſo, we will declare in this manner: We will deſcribe the Triangle A C B, which is that of which the Screw H I is generated, in ſuch ſort, that the Channel of the Screw is repreſented by the Line A C, whoſe Aſcent, or Elevation is determined by the Angle B A C, that is to ſay, if ſo be the Angle B A C be one third, or one fourth part of a Right Angle, then the Elevation of the Channel A C ſhall be according to one third, or one fourth of a Right Angle alſo: And it is manifeſt, that the Riſe of that ſame Channel A C, will be taken away, debaſing the Point C as far as to B, for then the Channel A C ſhall have no Elevation: And debaſing the Point C a little below B, the water will naturally run along the Channel A C downwards from the Point A towards C. Let us therefore conclude, that the Angle A, being one third of a Right Angle, the Channel A C



ſhall no longer have any Riſe, debaſing it on the Point C, for one third of a Right Angle.

Theſe things underſtood, let us unfold the Triangle about the Columb, and let us make the the Screw B A E F G, &c. which if it ſhall be placed at Right Angles with the end B in the water, turning it about, it ſhall not this way draw up the water, the Channel about the Columb being Elevated, as may be ſeen by the Part B A, but altho' the Columb ſtand erect at Right Angles, yet for all that, the Riſe along the Screw, folded about the Columb is not of a greater Elevation, than of one third of a Right Angle, it being generated by the Elevation of the Channel A C: Therefore, if we incline the Columb but one third of the ſaid Right Angle, and a little more, as we ſee I K H M, there is a Tranſition and Motion along the Channel I L: Therefore, the Water from the Point I to the Point L ſhall move deſcending, and the Screw being turned about, the other parts of it ſhall ſucceſſively diſpoſe, or preſent them ſelves to the Water in the ſame poſition as the part I L: Whereupon the Water ſhall go ſucceſſively deſcending, and in the end ſhall be found to be Aſcended from the Point I, to the Point H. Which, how admirable a thing it is, I leave ſuch to judge who ſhall perfectly have underſtood it.



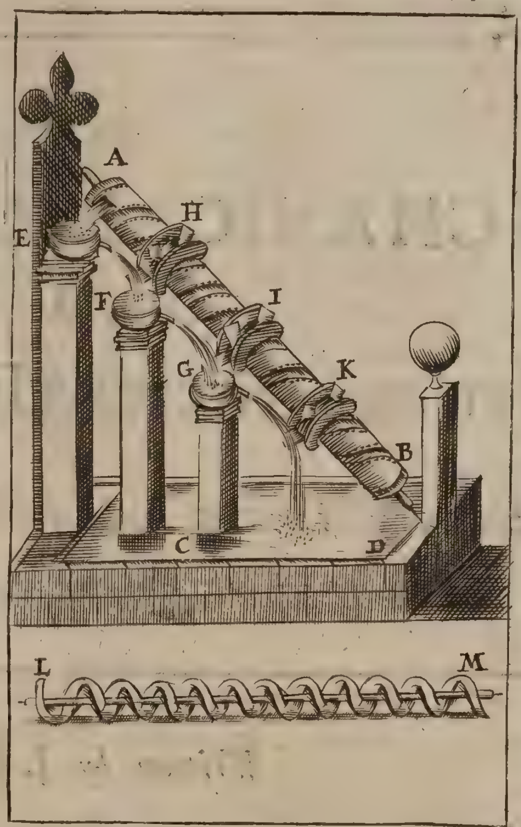

*How it hath been by ſome ſuppoſed, that from this Water Screw a Perpetual Motion may be contrived:*

For, *ſay they*, if there were but ſuch a Water-Wheel made on this Inſtrument, upon which the Stream that is carried up, may fall, in its Deſcent it would turn the Screw Round, and by that means convey as much Water up, as is required to move it; ſo that the Motion muſt needs be continual, ſince the ſame Weight which in its fall does turn the Wheel, is by the turning of the Wheel carried up again.

Or, if water falling upon one Wheel would not be forcible enough for this effect; why, there might be two or three, or more, according as the Length and Elevation of the Inſtrument will admit; by which means the Weight of it may be ſo multiplyed in the fall, that it ſhall be equivalent to twice or thrice that quantity of water which Aſcends; as may be more plainly diſcerned by the Figure.

In

In this Figure L M at the bottom, repreſents a Wooden Cylinder with Helical Cavities cut in it; which at A B is ſuppoſed to be covered over with Tin Plates, and three water Wheels upon it, as H I K; the Lower Ciſtern which contains the water, being C D. Now this Cylinder being turned round, all the water which from the Ciſtern Aſcends through it, will fall into the Veſſel at E, and from that Veſſel being conveyed upon the Water Wheel H, ſhall conſequently give a circular Motion to the whole Screw: Or if this alone ſhould be too weak for the turning of it, then the ſame water which falls from the Wheel H, being received into the other Veſſel F, may from thence again deſcend on the Wheel I; by which means the force of it will be doubled. And if this be yet inſufficient, then may the water which falls on the ſecond Wheel I, be received into the other Veſſel G, and from thence again deſcend on the third Wheel at K; and ſo for as many other Wheels as the Inſtrument is capable of. So that beſides the greater diſtance of theſe three Streams from the Center or Axis, by which they are made ſo much heavier; and beſides, that the fall of this outward water is forcible and Violent; whereas the Aſcent of that within, is natural: Beſides all this, there is thrice as much water to turn the Screw, as is carried up by it.




But on the other ſide, if all the water falling upon one Wheel would be able to turn it round, then half of it would ſerve with two Wheels.

Although what is here ſaid concerning the probability of effecting ſuch a Motion, yet Trial and Experience have diſcovered the contrary, and found it wholly inſufficient: And that,

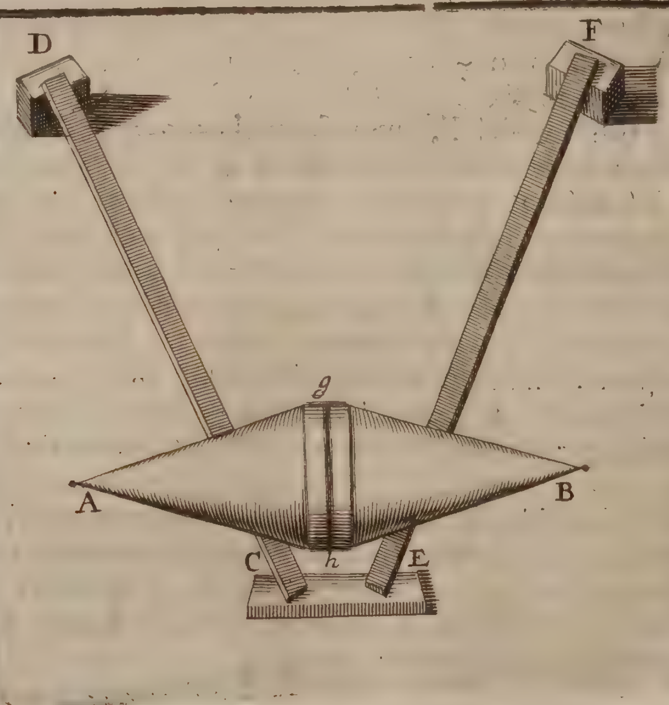
Firſt, For that the water that Aſcends will not make any conſiderable Stream in the fall. And

Secondly, This Stream (though multiplyed) will not be of force enough to turn about the Screw.

# A MECHANICAL PARADOX: OR, A New and Diverting Experiment.

## Whereby a Heavy Body shall by its own Weight move up a sloping Ascent.

*Written by* J. P.




THE Things necessary for this Experiment are, First, A Roller of Wood, turned in a *Lathe-Ink*, a Figure like as here is represented at A B, (*viz.*) of two Cones (or Sugar Loaves) abutting one against the other. Let the thickness in the middle (g h) be about 5 or

5 or 6 Inches, the length AB about 3 times the thickneſs; at the end A & B may be left two little Pins turned. 2. You muſt provide two ſtraight ſmooth Rulars about a Yard in length, and ſtrong enough to bear the weight of the Roller. 3. Laſtly, You muſt have three pieces of Wood to ſupport the ends of the Rulars; the firſt about two or three Inches thick, the other two (to ſtand at D and F) muſt be thicker than this firſt by ſomewhat leſs than half the Diameter of the Roller; ſo that if the Roller be 6 Inches Diameter, the firſt piece of Wood 2 Inches, then let the other 2 pieces be about 4 ½ Inches apiece. Being thus provided when you would try the Experiment, 1. Place the two thicker pieces upon a level Table almoſt the length of the Roller off of one another, as at D F, ſet the other piece of Wood almoſt the length of the Rular off of the other two. 2. Place the two Rulars with their ends upon the pieces of Wood in the manner as is repreſented in the Figure, with their lower ends near together, and the upper ends ſtradling. 3. Place the middle of your Roller between the two lower ends of the Rulars, and you will ſee (if you have placed all right) what you deſire, *viz.* The Roller will of it ſelf climb to the upper ends of the Rulars.

When you would divert any perſon with this Experiment, you may firſt put the Rulars Parallel, (or with lower ends as wide as the upper) and let it be ſeen how faſt the Roller will run down the Deſcent; which will make it the more ſtrange to ſee it afterwards climb the ſame Aſcent, by only bringing the lower ends nearer.

The reaſon of this (ſeeming) Aſcent of the Rhomb or Roller, is a real *Deſcent* or *Lowering* of its Center of Gravity, for tho' the way or line of the motion on the *Rulars* be an *Aſcent*, yet the line which the Roller deſcribes on its own ſurface is ſuch, that every point of it approaches nearer to the Axis of the Rhomb, the opening of the Rulars cauſing the Contact to be nearer to the ſmall ends of the two Cones; and conſequently, nearer to their Axis: Whereupon the Axis of the Rhomb is ſo much lower at the top of the Rulars, as their Elevation comes ſhort of the Semi-diameter of the Rhomb.

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CHAP.

## CHAP. IX.

### *Of other Engines, deduced from the former, for the moving of* Great *or* Heavy Bodies; *and of others for violent Motions.*

ALthough great and heavy *Works* may be effected by many Hands, according to the Verse,

*Multorum manibus grande levator opus:*

And as may be instanced in the Wild *Indians*, who have performed with Hand Labour (they not having the knowledge of Engines) such strange matters, as the removing of Stones of an incredible greatness.

*Arcosta* in his History of *Italy* relates, That he himself measur'd one at *Tiaguanaco* which was 38 foot long, 18 foot broad, and 6 foot thick. And he there also affirms, That in their stateliest *Edifices*, there were many other of far vaster Magnitude.

### I. *Of* Pullies.

1. It is Reported of *Archimedes*, that with an Engine of *Pullies*, to which he applied only his *Left-hand*, he lifted up 5000 *Bushels* of *Corn* at once; and drew a *Ship*, with all its *Lading*, upon the Land.

2. The same *Archimedes* with an *Instrument* called *Helix*, which *Rivoltus* supposes to consist of many *Screws*, Launched into the Sea that great Ship which *Hero* had built, without any other help. And what is here said may in some measure be verified by the Experiment following.

3. *How a Child, with a small Thread, or Sewing Silk, shall draw up a Weight of* 3 *or* 400 *Pounds.*

Prodigious is the force of Engines made by the Multiplication of Wheels; but this feat may be performed by a Common Kitchen Jack for Roasting of Meat, provided the Pullies be well fixed, and the Cord of sufficient strength: For let a *Man*, or a greater *Weight*, be fastned where the Jack-Weight usually is, then let a small silk *String* or *Thread* (nay a *Horses Hair*) be tied fast to one end of the *Fly* of the *Jack*, which put into a *Childs* Hand, he can with it easily turn the *Fly* about, which he continuing so to do, shall draw the *Man* or *Weight* up to what height he pleaseth.

But if the number of Wheels were any Invented, it would draw up a far greater Weight; nay, it might be made of sufficient strength to pull

pull a great *Oake*, or other *Tree*, out of the Ground by the Root. Nay, as *Archimedes* affirmed, That the whole *Globe of the Earth* might be moved were there any other place to fix his *Engine* in.

4. *How to contrive a* Ladder by Pullies; *whereby a* Man *may draw himself up to any assigned height.*

For the performance hereof, there is required only an *upper* and a *lower Rundle* or *Pullies*. To the uppermost of these at A, there should be fastned a sharp *Grapple*, or *Cramp* of Iron, which may be apt to take hold of any place where it lights: This part being first cast up and fastned, and the Staff DE, at the neither end, being put betwixt the Legs, so that a Man may sit upon the other BC, and take hold of the Cord at F; it is evident, that the weight of the Person at E, will be but equal to half so much strength at F, so that a man may easily pull himself up to the place required, by leaning but little more than half of his own weight on the string F: But if the Pullies be Multiplied, this Experiment might be performed with less Labour.

## II. *Of the* Sling.

The *Sling* is an Instrument or *Engine* of incredible force, and of such *swiftness*, that it exceeds that of a *Stone* thrown by the Hand, by how much the end of the *Sling* is farther off from the *Shoulder joint*, which is the *Center* of *Motion*; the Victory by *David* over *Goliah* is a sufficient Evidence of the force of this Engine. And again, in Holy Writ, we read of 700 *Benjamites Left-handed that could Sling a Stone at a Hairs breadth and not miss*. *Vigetius* relates, that it was usual this way to strike a Man Dead, and beat the *Soul* out of his *Body*, without so much as breaking his *Armor*, or fetching *Blood*. And it is likewise *Storied*, that there is a whole *Nation* among the *Indians*, who for their Excellency in the use of this Engine are Stiled *Baleares*; and they are so strict in Teaching this Art to their young Children, that the Mother will not give Meat to her Child, till (it being set at some distance) he could hit it with Slinging.

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# CHAP. X.

## *Of Engines of War used among the Ancients.*

THose among the Ancient *Romans* were principally of two sorts,

1. *Ballistæ*, Engines for Shooting or Casting of *Stones*.
2. *Catapultæ*, For the discharging of *Arrows*.

1. *Athenians*

1. *Athenus* mentions one of these *Balist*, that was proportioned into a Stone of three Talents Weight, each Talent being 120 pound (saith *Vitruvius*) and so the whole 360 pounds.

2. It is reported by *Plutarch*, that *Archimedes* cast a Stone into one of *Marcellus* his Ships, which was found to weigh 10 Talents; that is, 1200 pound weight.

3. Among the *Turks* there have been used such Instruments, for *Nab. Naudæus* tells us of one Bullet shot from them at the Siege of *Constantinople*, which was of above 1200 pound weight. This he affirms from the Relation of an Archbishop, who was then present and did see it.

4. Of the *Catapultæ*; some of them were proportioned to carry Spears of 12 Cubits long, which they would discharge with such force (saith *Amianus*) that the Weapons discharged from them were sometimes set on Fire by the swiftness of their motion.

5. It is related by Sir *Francis Bacon* in his 704 Experiment, that the *Bows* used now in *Turky* can strike an Arrow through a piece of *Steel* or *Brass* two Inches thick; being headed only with *Wood*, it will pierce Timber of 8 Inches thick, and hath pierced the sides of Ships.

6. *Barclay*, in his *Icon animorum*, affirms that he was an Eye-Witness how one of these *Bows*, with a little *Arrow*, did pierce through a piece of *Steel* three Fingers thick. These *Bows* (says the same Author) are somewhat like the *Long Bows* now in use with us, and bent by the immediate strength of one Man.

7. Mr. *John Greaves*, in his *Pyramadographia* reports, that he hath seen Turkish Bows of that strength, that they would pierce a Plank of 6 Inches thick.

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## CHAP. XI.

### *Of* Automonata, *or Self-Movers.*

OF these there are principally two kinds, *viz.*

1. Such as are moved by something which is *Extrinsical* unto their own *Frame*, As *Mills* by *Water* or *Wind*.

2. Such as receive their Motion from something that does belong to the *Frame* it self, As *Clocks*, *Watches*, &c. by *Weights*, *Springs*, or the like.

*Mills* by Wind and Water are commonly known, and to what uses they serve; as for Grinding of Corn, Making of Paper, Grinding of Brazil, Logwood, *&c.* Forging of Iron, *&c.* But there are some other Motions by *Wind* and *Air*, though not so common, yet of Excellent Curiosity. As for Instance.

1. In

1. In *Ægypt* there is a Statue of *Memnon* which makes a ſtrange noiſe whenever the Sun begins to ſhine upon it; which Statue, *Strabo* affirms he hath both ſeen and heard it. Much like unto this was that *Muſical Inſtrument* made by *Cornelius Dreble*, which being ſet in the Sun-ſhine, would of it ſelf render a ſoft and pleaſant Harmony; but being removed into the ſhade, would preſently become ſilent.

2. *Cardane* makes mention of a Spit that may be turned (without the help of Weights) by the Motion of the *Air* that aſcends the Chimney, and may be uſed for the Roaſting of many a great Joint of Meat. In which contrivance there are theſe conveniencies: Firſt, It makes little or no noiſe. Secondly, It needs no Winding up. Thirdly, It is much Cheaper than an ordinary Jack, it conſiſting only of a pair of *Sails*, one *Wheel*, to the *Axis* whereof the Jack-Line muſt be faſtned. This may be an Engine of good uſe in many other Domeſtick Affairs, as in Reeling of Yarn, Rocking of a Cradle, &c.

Unto theſe kind of Motions may be added all thoſe repreſentations of *Living Creatures*, as *Birds* or *Beaſts*, Invented by *Cteſibius*, which were for the moſt part performed by the motion of the *Air*, being forced up by Rarefaction by *Fire*; or elſe by compreſſion through the fall of Water, which by poſſeſſing the place of the Air, did thereby drive it to ſeek for vent.

3. The late Invention of the *Wind Gun*, which is Charged by the forcible compreſſion of *Air*, being injected through a *Syrenge*, the ſtrife and diſtenſion of the impriſoned *Air* ſerving by help of little *Falls* within to ſtop and keep cloſe the Vents by which it was admitted; the force of which Gun is almoſt equal to our common Powder Guns: For *Merſenus* ſaith, that he hath often found by frequent Trials, that a *Leaden-Bullet* from one of theſe Guns being ſhot againſt a Stone-Wall at 24 Paces diſtance, hath been beaten into a thin Plate.

4. The ſame Author (in the 31th Prop. of the ſame Book *Phænomena Pneumatica*,) whereby he will make the ſame Charge of Air to ſerve for the diſcharge of ſeveral *Arrows* or *Bullets* one after another, by giving the Air only ſo much room as may immediately ſerve for to impreſs a violence in ſending away the Arrow or Bullet.

5. *Boterus* mentions that *Sailing Chariots* are commonly uſed in Champion Countries, as in *China*, by which a Man may Sail on the Land as well as by a Ship on the Water. Amongſt theſe *Sailing Chariots*, that at *Scheveling* in *Holland* is very remarkable; it was made by the Directions of *Stephinus*, and is Celebrated by divers Authors. *Walchinus* affirms it to be of ſo great a ſwiftneſs for its Motion, and yet of ſo great Capacity for its Burthen, that it did far exceed the ſpeed of any Ship; and that in ſome few hours ſpace it would convey ſix or ten Perſons 20 or 30 *German* Miles, and all this with very little Labour to him that ſitteth at the Stern. One *Peireskius* an inquiſitive Man, Travelled to *Scheveling* for to ſee the Experience of this *Chariot*, and would often ſpeak of the Extraordinary ſwiftneſs of it: And ſaith (among other Excellencies of it) that in two hours time it would paſs from *Scheveling* to *Putten*, which are diſtant above 14 *Horaria Milliaria*; that is, more than 42 Miles.

6. Of this kind in *Holland* they have frequently other little Veſſels for one or two Perſons to go upon the Ice, having Sledges inſtead of Wheels, being driven by a Sail; the Bodies of them like little Boats, that if the Ice ſhould burſt they might yet ſafely carry a Man upon the Water, where the Sail would be ſtill uſeful.

## III. *Of ſuch* Automata's *that have their Motions from ſomething within their own Frames.*

1. Of the ſame kind with our *Clocks* or *Watches*, was that Sphere of Glaſs Invented by *Archimedes*, which did repreſent the Heavenly Motions, the Diurnal and Annual Motions of the *Sun*; the *Changes*, and other Aſpects of the *Moon*, &c. This is frequently Celebrated in the Writings of the Ancients, particularly by the Epigramiſt *Claudius*, &c.

*Jupiter in Parvo*, &c.

Thus *Engliſhed.*

IN *a ſmall* Glaſs *when* Jove *beheld the* Skies,
*He Smiles, and thus unto the* Gods *Replies*:
*Could Man ſo far extend his Studious Care,*
*To mock my Labours in a* Brittle Sphere,
Heaven's *Laws*, Man's *Ways, and* Nature's *Sovereign Right,*
*This Sage of* Syracuſe *Tranſlates to ſight.*
*A* Sol *within on various* Stars *attends,*
*And moves the quick Work unto certain ends.*
*A feigning* Zodiack *runs his proper* Year,
*And a falſe* Cynthia *makes new* Months *appear,*
*And now bold* Art *takes on her to Command,*
*And Rule the Heavenly* Stars *with Humane Hand:*
*Who can admire* Salmonean *harmleſs* Thunder,
*When a ſlight Hand ſtirs* Nature *up to* Wonder.

This Spherical Engine I cannot think to be of *Glaſs*, but rather of *Braſs* ſet on Work by Springs as the Movements of our *Watches*, and that it was incloſed in a *Caſe* of *Glaſs*, through which the Motions might be viſible. In imitation whereof there was lately made one by *Cornelius Dreble*, and preſented to King *James* I. of *England*. And like unto theſe *P. Ramus* Reports to have ſeen two at *Paris*, not of *Glaſs* but of *Iron*; one of which was brought by *Ruellius* the Phyſician from the Spoils at *Sicily*, and the other was recover'd by *Orontius* from the *Græcian* Wars.

### *Of Walking or Flying* Automata's.

1. Such were thoſe ſtrange Inventions attributed to *Dædalus*, Self-moving Statues, which (unleſs they were violently detained) would of themſelves run away. *Ariſtotle* affirms that *Dædalus* did this by putting

putting *Quickſilver* into them; it is more likely he did it with *Wheels* and *Springs* within.

2. Of this kind likewiſe were *Vulcan's Tripodes*, Celebrated by *Homer*, that were made to move up and down the Houſe, and fight with one another.

3. *Cardan* makes mention of an *Image* holding in its Hand a *Golden Apple*, beautified with many coſtly Jewels, which if any Man offered to take, the Statue preſently ſhot him to Death; the touching of which Apple ſerving to diſcharge ſeveral ſhort Bows, or other like Inſtruments couched in the Body of the Image.

4. *Walchinus* his *Iron-Spider* is very remarkable, which being but of an ordinary bigneſs, beſides the outward ſimilitude, which was very exact, had the ſame motions with a Living *Spider*, creeping up and down as if it had been alive.

5. I my ſelf remember, and have often ſeen it, a Figure of a *Dutch Froe* made; the Caſe of Silver about 5 or 6 Inches high, one Arm by her ſide, and in the other a Silver Cup, which Cup being filled with Wine, and her Face directed to the party Drank to, who would ſoftly Travel over the Table to the very Party; and when ſhe came to the edge of the Table, ſhe would there ſtand ſtill till the party took the Cup out of her Hand and Drank to another; and ſo to a 3d, 4th, 5th or 6th Party, or more, one after another. And thus would ſhe do for the ſpace of half an hour, beſides the times that ſhe ſtood ſtill between every Parties taking the Cup and Drinking.

6. There have been ſome Inventions alſo, which have been made, able to utter ſome certain Words; and ſuch are ſome of the *Ægyptian Idols* related to be: And ſuch was the *Brazen Head* made by Friar *Bacon*. And that Statue, in the framing of which *Albertus Magnus* beſtowed thirty years in the framing, who *Aquinas* coming to ſee, broke it, purpoſely, that he might boaſt, how that in one Minute he had ruin'd the Labour of 30 years.

## *Of Flying* Automata's.

1. The Wooden *Dove* made by *Archytas*, a Citizen of *Tarentem*, and one of *Platres* Acquaintance.

2. The Wooden *Eagle* framed by *Regiomontanus* of *Noremberg*, which by way of Triumph did fly out of the City to meet *Charles* the Fifth.

3. The Iron *Fly* made by the foreſaid *Regiomontanus*, which, when he Invited any of his Friends, would fly to each of them round the Table; and at length (as being weary) return unto his Maſter.

# CHAP. XII.

## *Of the* Magnificent Works *of the* Ancients, *and wherein they exceed these of our Age.*

I Shall here make a reictal of some of the largest *Monuments* of this Nature which are Recorded in the *Ægyptian, Jewish, Grecian* and *Roman* Histories. And

1. Amongst the *Ægyptians*, we read of divers *Pyramids*. *Herodotus* mentions one of them Erected by *Cheopes* an *Ægyptian King*, wherein there was not one Stone less than 30 foot long.

2. *Amasis*, another *Ægyptian*, made himself a *House* of one entire *Stone*, which was 21 Cubits long, 14 Broad, and 8 High

3. The forementioned *Amasis* is Recorded to have made the *Statue* of a *Finx*, or *Ægyptian Cat*, all of one Stone, whose *Length* was 143 foot, its *Height* 62 foot, and the *Compass* about it 102 foot.

4. *Pliny*, in his 37 Book, and 5th Chapter, Reports, that in one of the *Ægyptian Temples* Dedicated to *Jupiter*; there is an *Obelisque*, consisting of four *Emeralds*; which is 40 *Cubits High*, 4 *Cubits Broad* at the *Bottom*, and 2 at the *Top*.

5 *Diadorus Siculus*, Reports, that *Sesostris* an *Ægyptian* King, Erected in a Temple at *Memphis* Dedicated to *Vulcan*, two *Statues*, one for himself, the other for his Wife; both consisting of two several Stones; each of which *Statues* were 30 *Cubits* High.

6. Amongst the Jews, *Solomons Temple*, which for its *State* and *Magnificence*, (besides the great *Riches* of the *Materials*,) there were *Pillars* of *Brass* 18 Cubits high, and 12 Cubits about; and great and costly Stones for the Foundation of it; some of which *Josephus* tells us, were some 40, others 45 Cubits long.

7. The same *Josephus*, in the 6th Chap. of his 6th Book, tells us, that *Herod* built three Famous *Towers*, each 30 Cubits high, of White Marble, each Stone whereof was 20 Cubits Long; 10 Broad, and 5 Thick. These *Temples* were scituate upon a steep rising Ground, and *Hills* upon that; upon the Tops of which *Hills* these *Towers* were Erected.

8 *Pliny*, in the 14th Chapter of his 36 Book Relates, that in the *Ephesian Temple* Dedicated to *Diana*, there were 127 *Columbs* made of so many several Stones, each 60 foot high; which Stones were digged out of the Quarries in *Asia*. This Temple was fired seven times, the last time by *Erostratus*, only to get himself a Name to Posterity.

9. Amongst the rest, the *Brazen Colossus* at *Roads* must not be forgotten, which *Pliny* in the 3d Chapter of his 34th Book, Reports to be Erected over a *River*, the two Feet whereof were fixed on either side of the *River*, and of such a *Magnitude*, that it was 70 Cubits high, the *Thumbs* of it being so big, that no Man could grasp one of them

them about with both his Arms: And it ſtanding upright, a Ship might have paſſed betwixt the Legs of it, with all its Sails fully diſplayed: This *Statue* was thrown down by an Earth Quake, and the *Braſs* of it did Load 900 Camels. Now, ſuppoſing a *Camels* Burthen to be 1200 Weight, the Braſs in this Statue did contain 1080000 Pound Weight.

10. But above all theſe (had it been effected) that would have taken place, which was by a *Grecian* Architect propounded unto *Alexander*, for to have cut the Mountain *Athos* into the Form of a *Statue*, which in his *Right Hand* ſhould hold a *Town*, capable to receive ten thouſand Men, and in his Left, a *Veſſel* to receive all the *Water* that flowed from the ſeveral *Springs* in the *Mountain*: But *Alexander* (for what Reaſon I know not) embraced not the propoſal, and ſo the World muſt reſt ſatisfied without this *Wonder*. But had this *Statue* been Erected, according to the Propoſal, let us a little enquire into the *Magnitude* of ſome of the *Members* of this *Statue*. (1.) For the *Statue* it ſelf, that could not be higher than the *Mountain*, and the *Mountain* was not above *one Mile* in *Perpendicular height*. Therefore (2) The *Hand* muſt be the 10th part of the height, that is 500 foot, and conſequently, (3.) The *Breadth* thereof 250 foot. And, (4) The *Superficies* of the Hand would be 125000 *Square Foot*, in which ten thouſand Men were to be received, and that it would afford, (5.) Each *Man* 12 Foot and a half of *Ground*. And, (6.) For the other *Members* you may compare their *Magnitudes* by what hath been ſaid concerning the Proportions of the *Members* of Mans *Body*.

11. Amongſt the *Romans*, we Read of a *Coloſſus* of *Braſs*, made by the command, and at the Charges of *Nero*, which was 100 Foot high, which *Martial* calls *Syderius*.

*Hic ubi* Syderus *proprius videt Aſtra Coloſſus.*

12. It is ſtoried of *M. Curio*, that he Erected two *Theatres* ſufficiently capable of People, contrived moveable upon ſeveral Hinges. Sometimes there were *Plays* or *Shews* in each of them, neither being any diſturbance to the other; and ſometimes they were both turned about with the People in them, and the ends meeting together, did make a perfect *Amphitheatre*. So, that the *Spectators* which were in either of them might joyntly behold the ſame Spectacles.

13. At *Rome* were Erected ſeveral *Obeliskes*, each conſiſting but of one entire Stone; of which ſome were 40, ſome 80, and ſome 90 Cubits high. The choice of theſe were brought out of *Ægypt*, where they were dug out of ſeveral *Quarries* there, and being there wrought into Form, were afterwards (with great Charge and Labour) conveyed to *Rome*.

14. In the year 1586, there was Erected an *Old Obeliske*, which had been formerly Dedicated to the Memory of *Julius Cæſar*, it was one ſolid Stone, an *Ophite*, or *ſpotted Marble*; the *Height* of it was 117 foot, the *Breadth* at the bottom 12 foot, and at the Top 8 foot. Its whole Weight is Recorded to be 956148 Pounds, beſides the heavineſs of all thoſe *Inſtruments* and *Utenſils* that were employed about it, which (as it is thought) could not amount to leſs than 1040824 Pounds.

Pounds. This *Obeliske* was Tranſplaced at the Charges of *Pope Sixtus* the V. from the Left ſide of the *Vatican*, unto a more Eminent place, about a hundred foot off, where now it ſtands upon a Pediſtal 12 foot and a half high: And the height of the Gilded Croſs of Braſs, at the Top of the *Obeliske* is 19 foot and a half high. This great Work was done in a few days; by five hundred Men.

15. *Plammiticus* King of *Ægypt*, built a Labyrinth on the South ſide of the Pyramids, which contained within one continued Wall 3500 Perſons, (as *Herodotus* ſaith) and 12 Royal Palaces, all covered with Marble. The Labyrinth had only one Enterance, but innumerable turnings and windings, ſometimes one over another: The Building whereof was more under ground than above, the Chambers ſo diſpoſed, that the Doors upon their opening, did give a Report like a crack of Thunder. The main Entrance was all of white Marble, Adorned with ſtately Columbs and moſt curious Images. Being at the end, a pair of Stairs of 90 ſteps, conducted into a ſtately *Portico* ſupported by Pillars of *Theban* Marble, which was the Entrance into a Fa r and Stately Hall (the place of their General Convention) all of Poliſhed Marble ſet out with the Statues of their Gods.

16. The Houſe of *Nero*, which he called *Domum Aurum*, by *Suetonius* is thus deſcribed: In the Porch was placed a *Coloſſus*, ſhaped like himſelf of 120 foot high. The ſpacioutneſs of the Houſe was ſuch, that it had in it three Galleries, each of them a Mile long: A ſtanding Pool like a Sea, beſet with Buildings in manner of a City; Fields in which were Arable and Paſture Grounds, Vineyards and Woods, with a Multitude of Tame and Wild Beaſts of all kinds: In the other parts thereof all things were covered with Gold, and diſtinguiſhed with Precious Stones or Mother of Pearl: The Supping Rooms were Roofed with Ivory, moveable for the caſting down of Flowers, and Pipes in them for the ſprinkling of Oyntments: The Roof of the principal Supping Room was Round, which (like the Heavens) Day and Night moved round about. This Houſe when he had thus finiſhed and Dedicated it, he ſaid then, that he began to live like a Man.

17. *Pancirollus* Reports, that *Ptolomæus Philopater* built a Ship, or Galley which was 280 Cubits in length, 52 Cubits from the Keele to the upper Deck: It had 400 Banks or Seats for Rowers; 400 Mariners, and 4000 Rowers, and on the Deck would contain 3000 Souldiers. *Plutarch* in the Life of *Demetrius* ſaith, there were Gardens and Orchards on the Top of it.

### *Of the* Time, and Number of Men *employed in the* Building *of ſome of theſe* Magnificent Works.

1. In the making of one of the *Ægyptian Pyramids*, we Read, that three hundred and ſixty thouſand Men were employed for *twenty years*. And *Herodotus* tells us, that one *Million* (or ten hundred thouſand) of Men were as long in building another of them.

2. About the carriage of one Stone from *Amaſis*, the diſtance of 20 days Journey, there was for three years together employed 2000 choſen Men *Governours*, beſides many other under *Labourers*.

3. In

3. In the building of *Solomons* Temple, there were threeſcore and ten thouſand Men that bore burthens, and 80 thouſand *Hewers* in the *Mountains.*

4. The *Ægyptian* Temple was built by all *Aſia* joyning together: The 127 *Pillars* thereof were made by ſo many Kings, according to their ſeveral Succeſſions; the whole Work being not finiſhed under the ſpace of 215 years.

5. In the building of one of the *Pyramids*, there was expended for the maintenance of the *Labourers* with *Radiſh* and *Onions*, no leſs than eighteen hundred Talents, which is reckoned to be about 470000 *i. e.* four hundred and ſeventy thouſand pound Sterling.

6. It is Reported, that the making of the *Rhodean Coloſſus* (before ſpoken of) did coſt 300 Talents.

7. *Cleopes*, an *Ægyptian King*, is reported to have been ſo deſirous to finiſh one of the *Pyramids*, that having ſpent all about it he was worth, he was forced at laſt, to proſtrate his Daughter, for neceſſary maintenance.

8. We Read of *Ramiſes*, another *Ægyptian* King, how that he was ſo careful to Erect an *Obeliske*; about which he had employed twenty thouſand Men; that when he feared, leaſt through the negligence of the *Artificers*, or weakneſs of the *Engine*, the Stone might fall down and break, he tied his own Son to the Top of it, that ſo the care of his ſafety might make them more circumſpect in their buſineſs.

*An Account of the* Heights *of ſeveral* Obeliskes, Steeples, Pyramids *and* Pillars *in the* World, *according to our* Engliſh Meaſure, *moſt of which are now in being.*

1. St. *Pauls* Steeple in *London*, when the *Spire* was on it, (which was Fired by Lightning *Anno* 1555) the *Stone Work* was 260 foot high, and the *Spire* as much, which was 520 foot in all.
2. The Steeple at *Cremona* in *Italy*, is 528 foot high.
3. The *Ball* upon St. *Peters* in *Rome*, is 466 Feet.
4. The *Steeple* at *Roan* in *Normandy*, is 399 Feet.
5. The *Steeple* at *Strasburg* in *Germany*, is 431 Feet.
6. The *Steeple* at *Landhoven* in *Bavaria*, is 451 Feet.
7. The *Steeple* at *Medera* in *Italy*, is 279 Feet.
8. The *Tower Aſinel* in *Banonia* in *Italy*, is 316 Feet.
9. The *Cupulo*, or *Lanthorn* at *Genua*, 324 Feet.
10. The *Higheſt* of the *Pyramids*, 1350 Feet.
11. The *Loweſt* of the *Pyramids*, 883 Feet.
12. *Boſton Steeple* in *Lincolnſhire* all of Stone, and without any *Spire*, is 264 Feet.
13. The height of the *Obeliske* in *Rome*, removed by *Sixtus* the V. is 78 Foot high.
14. The *Columb* or *Monument*, Erected in Memorial of the great Conflagration in *London*, *Anno* 1666, wherein 13200 Houſes, 89 Pariſh Churches were burned, all which ſtood upon 437 Acres of Ground. The *Monument* is of Stone; the *Pediſtal* whereof is 27 foot broad, and the height of the *Columb*, from the Ground (beſides the Foundation) to the Top of the *Flame*, is 202 Foot, the Circumfe-

rence

rence of the *Shaft* is 47½ Foot, its Diameter 15 Foot, and of the hollow Cylinder 9 Foot, with *Steps* up to the Top, and an hollow *Newel* from the Top to Bottom.

# CHAP. XIII.

*An Account of some such admirable Pieces of Work of several kinds, made by several eminent Artists, both Ancient and Modern; which have been by divers Historians and others related; and of some in this our present Age.*

1. Regiomontanus, a Famous *Geometrician* of *Norimberg* made an *Eagle* of Wood, and a *Fly* of Iron —— This Eagle he put to Flight out of the City, which raised it self aloft into the Air, and met the Emperour *Maximilian* a good way off, as he was coming towards it; and having saluted him, returned again to the City Gates. The Fly, at a Feast, flew forth of his Hand, and taking a Round about the Table, returned to his hand again. Of these two admirable Pieces of Wormanship, (performed by Geometrical Proportion,) *Du Bartus* thus Writeth.

*Why should not I that* Wooden Eagle *mention,*
*A Learned* Germans *late admir'd Invention;*
*Which Mounting from the Fist that framed her,*
*Flew far to meet an* Almain *Emperour;*
*And having met him with her Nimble Train,*
*And wearied Wings; turning about again;*
*Follow'd him close, unto the City Gate*
*Of* Norimberg, *whom all their Shews of State,*
*(Streets hang'd with Arras, Arches Rarely Built:*
*Gray-Headed Senate, and Youths Gallantries;)*
*Grac'd not so much, as did this one Device.*

Then he Describes the FLY as followeth,

*Once as the Artist, more with Mirth than Meat,*
*Feasted some Friends, whom he Esteemed Great:*
*From under's Hand an Iron Fly flew out,*
*Which having flown a perfect Round about,*
*With weary Wings Returned to her Master,*
*And (as Judicious) on his Arm he plac'd Her.*
*O! Divine Wit, that in the Narrow Womb*
*Of a small Fly, could find sufficient Room,*
*For all those Springs, Wheels, Counterpoise and Chains,*
*Which stood instead of Life, and Spur and Reins.*

2. Doctor

2. *Doctor Hackwell* in his Third Book of his Apology of the Power and Providence of God, in the Government of the VVorld—*Verstegan* in his Antiquities, *Chap.* 2.— And *Knowls* in his Turkish History, *Pag.* 513. Make mention of a Silver Sphere, which was sent by the Emperour *Ferdinand*, to *Solyman* the Great Turk: It was carried (Unframed) by Twelve Men, and Re-framed in the Grand Signior's Presence by the Maker of it; who also delivered him a Book containing the Mystery of using it. Of which Sphere *Du Bartus* thus VVriteth.

*Nor may we smother, or forget ungrately*
*The Heaven of Silver that was sent, but lately*
*From* Fardinando, *as a Famous Work*
*Unto* Bizantiam, *to the* Greatest *Turk*;
*Wherein a Spirit, still moving to and fro,*
*Made all the Engine orderly to go,*
*And tho' th'one Sphere did always slowly Glide.*
*And contrary, the other swiftly Slide:*
*Yet still the Stars, kept all their Courses even*
*With the True Courses of the Stars in Heaven.*
*The Sun there shifting in the Zodiack,*
*His shining Houses never did forsake*
*His pointing Path. There in a Month his Sister*
*Fulfill'd her Course, and changing oft her Lustre,*
*And Form of Face, (now Larger) Lesser soon;*
*Follow'd the Changes of the other Moon.*

III. *Archimedes* the *Syracusan* Mathematician, who flourished *Anno Mundi* 3739, and before the Nativity of Christ 203, who is said to have composed a Sphere of Transparent Glass; representing to the Life the whole Frame of the Heavens; wherein the Sun, Moon and Stars, with their true Motions, Periods and Limits were shewed to the Sight, in such sort as if it were Natural: Of which Sphere *Claudius*, an Eminent Poet in the time of *Theodosius* the Emperour, who was born at *Alexandria*, and flourished *Anno Christi* 390, Elegantly VVrote in his Epigrams; which is thus excellently Translated into English, by our Late English Poet, Mr. *T. Randolph.*

*Jove saw the Heavens, Fram'd in a little Glass,*
*And Laughing to the Gods, these Words let pass:*
*Comes then the Power of Mortal Cares so far;*
*In Brittle Orbs, my Labours Acted are.*
*The Statutes of the Poles, the Faith of things,*
*The Laws of Gods, this* Syracusian *brings*
*Hither by Art; Spirits inclos'd attend*
*Their several Spheres; and with set Motions bend*
*The Living Work; each year the feigned Sun,*
*Each Month returns the Counterfeited Moon;*
*And viewing now her World, bold Industry*
*Grows Proud, to know the Heavens his Subjects be,*
*Believe,* Salmonius *hath false Thunder thrown,*
*For a poor Hand is Natures Rival grown.*

D IV. One

IV. One *Mark Scalios* a Black-Smith, in the year of Christ 1573 ; made a Lock, which confifted of eleven pieces of Iron, Steel and Brafs, all which, together with a Pipe Key to it, weighed but one Grain of Gold—— The fame party alfo, made a *Chain* of *Gold*, confifting of 43 Links, to which he faftned the forementioned Lock and Key, and putting the Chain about the Neck of a Flea, which drew them all about with eafe ; and all thefe particulars weighed together but one Grain and a half.

V. One *Colicrates* would make Ants, Pifmires, and other fuch like Creatures of Ivory, fo fmall, that others could not difcern the parts thereof one from another by the bare Eye, without the help of Glaffes.

VI. One *Mermicides* (another excellent worker in Ivory,) made a Coach with four Wheels, and as many Horfes ; which a Fly might cover with her Wings,—— He alfo made a Ship, with all her Tackling to it, which a fmall Bee would cover with her Wings.

VII. One *Cornelius van Drebble*, a Dutch-man (in imitation of *Memnons* Statue) made a kind of Organ that would make an excellent Symphony of it felf, being placed in the open Air, and clear Sun, without the Fingers of an Organift ; but in a fhady place it would yield no Mufick, but only where the Sun Beams had the Liberty to play upon it.

VIII. One *Janellus Tarrianus*, a Great Mathematician, for to Recreate the Emperour *Charles* the V. would oftentimes delight him, by fending fometimes, Wooden Sparrows into the Emperours Dining Room, which would Fly about that, and return———Sometimes he would caufe little Armed Men to Mufter themfelves upon his Table ; and Artificially to move according to the Difcipline of War.

IX. There was an Artificer in *Rome*, who made Veffels of Glafs of fuch a Temper, that they were as little liable to be broken, as thefe of Gold or Silver. This Artificer made a Veffel of this pure fort of Glafs, and prefented it to *Tiberius Cæfar*, the then Emperour: The Gift was received, and the Artift applauded ; and that he might gain more Applaufe, he defires the Veffel again, and threw it with great Violence againft the ground, whereby it received no more damage than the like Veffel made of the folideft Metal would have fuftained thereby ; at which *Cæfar* was aftonifhed : But the Artificer drew an Inftrument out of his Bofome, wherewith he fuddenly reduced it to its former fhape : At the fight whereof, the Emperour was much moved, and enquired of the Artift, whither there were any other befides himfelf were privy to the like tempering of Glafs ? When he had told him no, he commanded his Head immediately to be ftricken off: Saying, fhould this Artifice come once to be known, Gold and Silver would be of as little Value as Stones in the Street.

X. *Knolls* in his Turkifh Hiftory, *Pag.* 1253 Relates, (long after the forementioned) *Viz.* in *Anno* 1610, that amongft other rare Prefents then fent from the *Sophy* of *Perfia* to the King of *Spain*, were Six Glaffes of Malleable Glafs, fo exquifitely tempered, that they could not be broken.

XI. At *Dantzick*, a City of *Pruffia*, one Mr. *Harrifon* fent a Mill, which without help of Hands did faw boards, having an Iron Wheel which did not only drive the Saw, but did alfo hook in the boards,

and

and drive them out, to and from the Saw——Dr. *John Dee*, in his Mathematical Preface before *Euclides Elements*, mentions the like seen by him in *Prague*; but whither the Mill before mentioned, or that which he see at *Prague*, moved by Wind or VVater, is not set down by either of them.

XII At the Mint of *Segoria* in *Spain*, there is an Engine that moves by water, so made, that one part of it distendeth an Ingot of Gold into that breadth and thickness, as is required to make Coyn of. It delivereth the Plate that it hath wrought, into another that Printeth the Figure of the Coyn upon it; and from thence it is turned over to another, that cutteth it according to the Print in due shape and weight. And lastly, the several Pieces fall into a Receiver in another Room; where the Officer, whose charge it is, finds it ready Coyned.

XIII. *Oswaldus Morhingerus*, made 1600 Dishes (or Platters rather) of turned Ivory, so small and little, so thin and slender, that all of them were included at once in a Cup turned out of a Pepper Corn of the ordinary size. This Piece was carried to *Rome*, and shewed to Pope *Paul* the V. who (by help of Spectacles) told them all distinctly.

XIV. *Johannes Baptista Perrarius*, a Jesuit, had in his Possession, not long since, Cannons of VVood with their Carriages, VVheels, and other Military Furniture; of which 25 of these, and 30 Cups turned out of wood, were all at once contained in one Pepper Corn, which exceeded not the common bigness.

XV. *George Whitehead*, an English Man, made a Ship with all her Tackling, to move it self on a Table, with Rowers plying the Oars; a VVoman playing on the Lute, and a little VVhelp creeping on the Deck. *Schottus* relates this in his History of Man, *Chap.* 12.

XVI. About the year 1649 or 50, one *Fromanteel* an English Man (though of Dutch Parentage) made here in *London* for Sr. *Parston*, a little Figure in Silver, of a VVoman in Dutch Habit, holding upright in her two Hands a Silver Cup, which would hold about the tenth part of a Pint of VVine. This Figure Sir *Parston* called his Froe (in respect of her Habit) and after Dinner, (for the Entertainment of his Friends) while his Servants were at their Dinner, would call for a Bottle of VVine, and his Froe to wait at his Table in his Servants Absence; which being brought, he would take the Cup out of his Froes Hands, and fill it with VVine; then drinking to one of his Friends on the other side of the Table, he would fill the Cup, and put it into the Froes Hands again, and directing her Face to the Person he drank to, the Froe would move of her own accord, cross the Table, to the party drank to; and when she came to the very edge of the Table, (till some part of the Skirt of her Garment hang over) she would there stand still; till the party drank to, took the Cup out of her Hands, and he drinking to another, filled the Cup again, and directed the Froe to whom he drank; to whom she would directly go as before; and would thus continue going throughout the Table. This Figure have I often seen, and been at the Table when the Experiment was put in practice.

XVII. There was one in Queen *Elizabeth's* days, that wrote the Ten Commandments, the Creed, the Pater-Noster, the Queens Name, and the Year of our Lord, within the Compass of a Penny; and gave with

it a pair of Spectacles, by help whereof the Queen did distinctly discern every Letter.

XVIII. Since which time, Namely in the Year of our Lord 1656, one *Abraham Switzer*, born in the Parish of St. *Andrews* in *Holborn*, *London*, (by profession an Ingraver, or Cutter of Figures, Pictures or Schemes to print in Books, in *Box* or other VVood.) Did write in a Roman Hand in words at Length, these following particulars; *Viz.* 1. *Every good and perfect Gift comes from above.* 2. *Lord teach us to Pray.* 3. *The Lords Prayer.* 4. *The Creed.* 5. *The* 134 *Psalm.* 6. *Lord Preserve the Church.* And Lastly, in the Center, or middle; (for it is written in a Spiral or Serpentine Line, with a Red Line, between every Line, for the better guiding of the Eye in Reading.) 7. *All the Figure of a Deaths Head*, which, one of the Farthings (then in use) would easily cover. This writing was written in the 61 year of his Age, and my own Father when I first shew'd it to him, being then 63 years of Age, could Read without Spectacles (for he never used any) and this piece of small writing I have this present time, *Febr.* 16. 1690 by me, to be seen of any that shall desire it.

XIX. One *Francis Alumnus* wrote the Apostles Creed, and the 14 first Chapters of St. *Johns* Gospel, in the Compass of a Peny, and this was done in full words, in the presence of the Emperour *Charles* the V.

XX. One *J. Rich*, an English Man, and an excellent Steniographer, did in the year 1671, take in Short-Hand, a Sermon, word for word, Preached before King *Charles* the II. at *Whitehall*, by a Bishop (whose Name I do not remember) in less than half a quarter of a sheet of Paper; and afterwards shewed it to the Bishop, and did distinctly Read it before him, who acknowledged it to be his, and that he did think there was not one word added or diminished, from what he then Preached: VVhereupon he wished he would present some piece of his Art to the King; upon which, he wrote the same Sermon in a little Book of Six Leaves of Fine Paper, and had it bound in Crimson Sarcenet, with Silver Clasps and Corners upon the Cover; all which Book and Cover was less than the nail of his little Finger; which Book he afterwards presented to the King.

XXI. *Wind Guns*, or *Muskets* are a Rare and Late Invention, which will shoot Bullets without Powder, or any thing else but *Wind*, or *Air* compressed in the bore of it, or injected by a Spring: These will discharge with as much force as others with Powder.

XXII. In the Duke of *Florentines* Garden at *Pratoline*, is a Statue of *Pan* sitting upon a Stool, with a wreathed Pipe in his Hand, and Syrinx beckoning him to play upon it. *Pan* putting away his Stool, and standing up, plays upon his Pipe; which done, he looks upon his Mistress, as expecting thanks from her, but his expectation being frustrate, he sits down with a sad Countenance.

XXIII. There is also in the same Garden another Statue, of a *Laundress* beating a Buck, and turning the Cloaths up and down with her Hand and Battledore, with which she beats them in the water.

XXIV. There is also the Statue of Fame loudly sounding her Trumpet. An Artificial Toad creeping up and down. A Dragon bowing down his Head to drink water, and then vomiting up again: VVith divers other pieces of Art.

XXV. In

XXV. In Cardinal *Farraras* Garden at *Tivoli* near *Rome*, are the Repreſentations of ſundry Birds ſitting on the Tops of Trees; which by ſecret conveyances of water through the Trunks and Branches of the Trees, are made to Sing and clap their Wings; but at the ſudden appearance of an Owl out of a Buſh, they immediately all become Mute and Silent: Theſe were made by *Claudius Gallus*.

XXVI. In *Dantzick* in *Poland*, there was ſet up a rare Engine for weaving of four or five Webs at the ſame time, without any humane help, and would work Night and Day. This Invention was ſoon ſuppreſſed, and the Inventor ſecretly made away.

XXVII. *Hadrianus Junius* ſaw at *Mickland* in *Brabant*, a Cherry-Stone cut in the form of a Basket; wherein were fourteen pair of Dice, each with their ſeveral Spots, eaſily to be diſcerned by a good Eye.

XXVIII. In the year 1524, the City of *Colonia Agrippina*, was Painted with much exactneſs, and yet ſo little, that a Fly might cover it.

XXIX. In the Reign of *Anastacius Dicorus*, the Famous *Geometrician* and *Aſtronomer Proclus*, made burning Glaſſes of that admirable force, that therewith he burnt (at a great diſtance) the Ships of the *Myſians* and *Thraſians* that had blocked up the City of *Conſtantinople*.

XXX. One *Peter de Peene*, by Profeſſion a Printer, made a Printing Preſs, of VVood and Iron, with all the Members belonging thereunto, which was no bigger than a common Hour Glaſs, and in it was a form of Letters, conſiſting of twelve Lines of Verſes, written in the Praiſe of that Famous Art or Myſtery of Printing, which this Preſs (as ſmall as it was) would Print off; which Preſs my ſelf have often ſeen in *London*: And this *Peter de Peene* was adviſed (he being but a poor Man) to put this Preſs into a Box, with ſome Ink and Letters, and go about the Countries to ſhew the Art of Printing to the Country People, and to Print their Names either in Red, Black or Gold upon Paper, Parchment, or Satten Ribband.

XXXI. The Duke of *Holſted* had made in the City of *Gottorp*, a double Globe of Copper, which was ten foot and a half Diameter, ſo that within it ten Perſons might ſit at a Table, which(with the Seats about it) hangeth at one of its Poles: In which Globe, a Man may ſee (by means of an Horizontal Circle within the Globe) how the Sun and Stars move of themſelves through the Degrees of the Eclipticк, and their Riſing and Setting regularly. The moti n of this Globe exactly followeth that of the Heavens, and deriveth that motion from certain Wheels and Pinnions, driven by water, which is drawn from a Mountain not far off, and let in as it requireth More or Leſs.

XXXII. One *Linus*, an Engliſh man, of the Society of *Jeſus*, had a Vial Glaſs of water, wherein a little Globe did float, with the 24 Letters of the Alphabet deſcribed upon it: In the inſide of the Vial was a S:yle or Index, to which the Globe did turn and move it ſelf at the Period of every Hour, with the Letter which denoted the Hour of the Day or Night ſucceſſively.

XXXIII. The ſame *Linus*, in *Anno* 1668, came over into *England*, (by way of Diſguiſe, in Habit of a Country Gentleman) and in *Anno* 1669, did make in the Kings Privy Garden at *Whitehall*, a Pyramidical Dial. This Dial did ſtand upon a Pillar, or Pediſtal of Stone, and

and consists chiefly of Six Parts or Pieces, one less than another, and placed one above another, in form of a Pyramis.——— The whole Fabrick contained 113 Dials, some Plain, some Concave, some Convex, some Upright, or Vertical; some Inclining, some Reclining; some Globular and Hollow; some covered with Glass, *&c.* Some of these shew the common Hour of the Day, others the *Jewish*, others the *Babylonish*, others the *Italian* Hour. Some shew the Suns Declination, others the Suns Altitude, others the Suns Azirnath, others the Suns Rising, others the Suns Setting, others the Amplitude, some the Day of the Month, *&c.* Some by Fire, some by Water, some by Earth, and some by Air. In some of these Dials you shall see the Hour Lines, but no Stile, in some the Stile but no Hour Lines; in some neither Stile nor Hour Lines; and in some both Stile and Hour Lines. Infinite Varieties there were upon this Pyromis, too many here to recite; but for such as would know more concerning this Piece of Art, may have recourse to my Book of Dialling in *Folio*, *Pag.* 323, *&c.* where there is a Figure of the whole Pyramis, and a Description of every particular Dial upon it. This Pyramis stood in the Garden abovesaid about 18 Months, and then in a Frolick much Battered and Defaced, so that there is now nothing of it to be seen.

XXXIV. I saw, *saith my Author*, at *Legorn*, a Clock brought thither by a *German*, to be sold, which had so many Rarities in it, as I should never have believed, if my own Eyes had not seen it: For, (besides an infinite Number of strange Motions which appeared not at all to the Eye) you had there a company of Shepherds, some of which played on the Bag-Pipes, with such Harmony and Excellent Motion of the Fingers, as that one would have thought they had been alive; others Danced by Couples, keeping exact time and Measure; whilst others Leap'd and Capred up and down, with so much of Nimbleness, that my Spirits were wholly Ravished with the Sight.

XXXV. *Copernicus* made a Clock, in which there was not only to be heard a Number of different Noises, occasioned by its various Motions; but also (most exactly to be discovered) the circutions of all the Cœlestial Orbs; the distinction of Days, Months, and Years: There the Zodiack did explicate its Signs; so performing the Circle of the Year; there the playful *Ram* began the Spring; *Cancer* produces the Summer; *Libra* inriches it with Autumn; and *Capricorn* makes the Winter. Here also the Moon changes in the *Nones*, shines out more Bright in the *Ides*; and shamefully conceals her Conjunction with the Sun in the *Calends*. But, besides all these, there were produced into the Scene, upon the Entrance of every hour made shew of some Mystery of our Faith. The first Creation of Light, the powerful separation of the Elements, and all other intermediate Mysteries he had traced upon this Engine, even to the Great Eclipse that was when our Saviour suffered upon Mount *Calvary*, *&c.* for to insist upon the particulars were the Work of an Age.

XXXVI. There is a Clock at *Strasburg*, invented by *Cornelius Dasipodius* in the year 1571. Before this Clock stands a Globe on the Ground, shewing the Motions of the Heavens; Namely, of the Heaven carried about by the first Mover in 24 Hours; of *Saturn* in 30 years, of *Jupiter* in 12, of *Mars* in 2, of the *Sun*, *Venus* and *Mercury* in

in one, and of the *Moon* in a Month. In the Clock it ſelf there be two Tables, ſhewing the *Eclipſes of the Sun* and *Moon*, from *Anno* 1573 to 1624. There is alſo a third Table, which conſiſteth of three Parts: In the firſt Part, the Statues of *Apollo* and *Diana* ſhew the courſe of the year, and the Day thereof: The ſecond ſhews the Year of our Lord, and of the World, the Hour and Minute of the Day. The third Part hath the Geographical Deſcription of all *Germany*, and particularly of *Strasburg*, and the Names of the Inventor, and all the Work-Men. In the middle Frame of the Clock is an Aſtrolabe, ſhewing the Sign in which each Planet is every day; and there be the Statues of the Seven Planets, upon a round Piece of Iron lying flat, ſo that every Day that Planet which Denominates the Day, comes forth, the others being all hid; as upon Sunday the *Sun*, *Monday* the *Moon*, *&c.* And there is a Terreſtrial Globe upon which the Hour, half Quarter and Minutes are ſhewed. There is alſo a Skull of a Dead Man, and the Statues of two Boys, whereof one turns the Hour-Glaſs every Hour when the Clock hath done ſtriking; and the other puts forth the Rod in his Hand at each ſtroke of the Clock. There are alſo the Statues of the *Spring*, *Summer*, *Autumn* and *Winter*, and many Obſervations of the *Moon*. In the upper part of the Clock, are the Statues of four Old Men, which ſtrike the Quarters of Hours; the Statue of Death coming out at each Quarter to ſtrike, but being driven back by the Statue of *Chriſt*, with a Sphere in his Hand for three of the Quarters; but at the fourth Quarter, that of *Chriſt* goeth back, and that of Death ſtriketh with a Bone in his Hand, and then the Chimes begin. On the Top of the Clock is an Image of a Cock, which twice in a day Croweth aloud, and chappeth his Wings. Beſides, this Clock is Beautified with many Rare Pictures, and being in the inſide of the Church carrieth another Frame to the outſide of the Wall; wherein the Hours of the Sun, the Courſe of the Moon, the Length of the Day, and ſuch other things, are ſet out with great Art.

XXXVII. The forementioned *John Fromanteele*, in the year 1649, did make a Table Clock with Springs, for Mr. *Dudley Palmer* of *Grays Inn*, which beſides the Hour and Minute of the Day, there was ſhewed upon the Dial Plate, the time of the Suns *Riſing* and *Setting*, with the *Length* of the Day and Night; the *Suns Declination*, his *Amplitude*, his *Declination*, and other things relating to the Courſe of the Sun. This Clock gives one ſtroke upon a ſmall Bell every *Minute*, and at every Quarter 2, 4, 6 and 8, ſtrokes upon a bigger Bell, and upon a third Bell, at every *Quarter* is repeated the preceding *Hour*, and at every third Hour the Chimes went; which were ſo contrived, that they Rang 12 ſeveral times, by the ſhifting of three ſeveral Barrels, 4 Tunes upon each Barrel. This Clock I have often ſeen, and had ſome Hand in the making of it.

*The End of the Mechanical Part.*

# Statical RECREATIONS.

## CHAP. I.

### *Of the Art STATICAL.*

THE *STATICKS* is defined to be an *Art Mathematical*; which demonſtrateth the Cauſes of *Heavineſs* and *Lightneſs* of all Things: And of *Motions* and *Properties* belonging to *Heavineſs* and *Lightneſs*.

So that by this Art, *Spheres* or other *Regular Bodies* may be *meaſured*, by having their *Quantity Ponderal*, according to any *Metal* and *Weight* aſſigned;) or, by having their *Quantity Dimentional*, (according to any aſſigned *Meaſure*;) there being the ſame Mathematical Reaſon of theſe two *Quantities*: And ſo they are by Mathematicians compared together in ſeveral kinds of *Bodies*; or divers kinds of *Bodies* are compared together among themſelves in this twofold *Reaſon* of *Quantity*: Viz. *Magnitude*, or *Dimenſion*; and *Gravity*, or *Ponderoſity*. So that theſe two do proportionally anſwer each other, inſomuch that the one may be deduced from the other; as *Gravity* from *Magnitude*, and *Magnitude* from *Gravity*: Or *Weight* from *Solid Meaſure*, and *Solid Meaſure* from *Weight*.

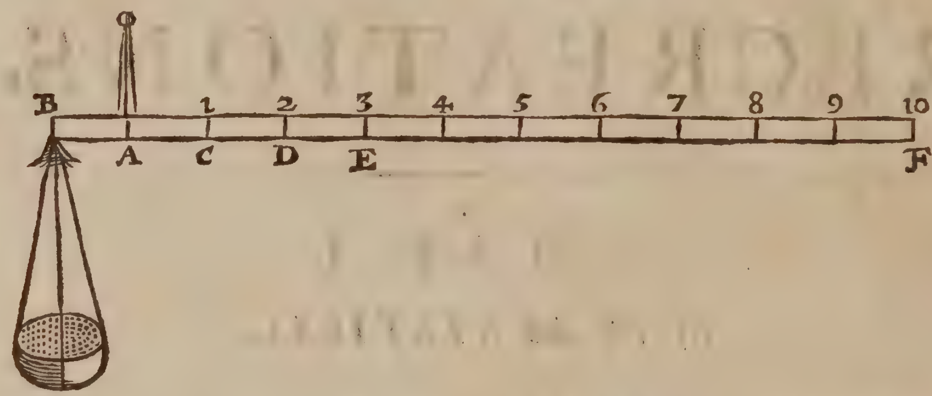
And from hence are deduced theſe following *Theorems* of *Marinus Ghetaldi*, in his Tractate called *Archimedes Promotus*.

## CHAP. II.

### *Concerning the Ballance.*

THE firſt Inventor of this *Statical Faculty*, commonly called *Libra*; or the *Ballance*, is attributed to *Aſtrea*, who is therefore Deified for the Goddeſs of *Juſtice*; and that Inſtrument is advanced among the Twelve *Celeſtial Signs*, and in that part of the *Zodiack*, to which, when the Sun cometh, it makes the *Days* and *Nights* of *equal Length* throughout the whole World.

The chief End and Uſe of this Inſtrument, is for the diſtinction of ſeveral *Ponderoſities*: For the underſtanding whereof it is to be noted, That, if the Length of the *Sides* in the *Ballance*, and the *Weights* at the *Ends* of them, be both mutably *equal*, then the *Beam* will be in an *Horizontal* Situation: But, if either the *Weights* alone be *Equal*, and not their *Diſtance*; or the *Diſtance* alone, and not the *Weights*; then the *Beam* will accordingly *decline*. As in the Figure.



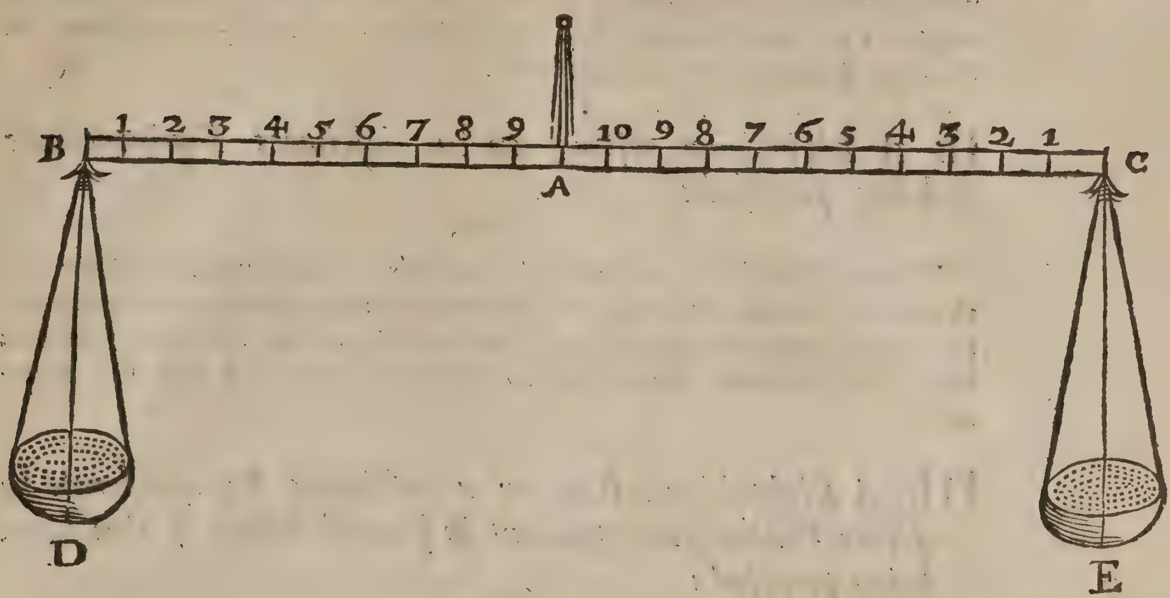

In which *Ballance*, ſuppoſe an *equal Weight* at C, to that at B, (both which Points are equidiſtant from the *Center* A) it is evident, that then the *Beam* BF will hang *Horizontally*: But if the *Weight* at C be unequal to that at *B*; or, if there be an equal *Weight* at D, or E, or any other of the unequal Diſtances noted upon the *Beam*; the *Beam* muſt then neceſſarily *decline*.

And with ſuch a kind of *Ballance* as this, it is uſual with *one Weight* only, to *weigh*, or *meaſure*, ſundry different *Gravities*, whether *more* or *leſs* than that by which they are *meaſured*. And thus by the Figure here deſcribed, a Man may (with *one Pound* alone) weigh any other Body, or Subſtance, within *ten Pounds*; becauſe the *heavineſs* of any *Weight* doth increaſe proportionably to its *Diſtance* from the *Center*. And thus, *one Pound* at D, will equiponderate *two* at B, becauſe the *Diſtance* AD, is *double* to that at AB. And for the ſame Reaſon, *one Pound* at E, will equiponderate *three Pound* at B; and *one Pound* at F, unto *ten* at B; there being the ſame diſproportion between their ſeveral *Diſtances*.

This kind of *Ballance* is of great Antiquity; *Ariſtotle* giving it the Name of φάλαγξ. It is alſo called *Romana Statera*; and now commonly, the *Stillyard*.

From what hath been ſaid, it is eaſie to apprehend, how *falſe Ballances* may be compoſed; too often uſed, and ſo much condemned by *Salomon*, Prov. XI. 1. XVI. 11. XX. 10. 23. as being *an Abomination unto the Lord*. For, if the *Sides* of the *Beam* be not *equally* divided, As ſuppoſe one have 10 *Parts*, and the other 11 of the ſame *Parts*, then any two *Weights* which differ according to this Proportion: as *Pappus* in his Third Book of *Mathematical Collections* obſerves: The *Heavier* being placed on the *Shorter* Side, and the *Lighter* on the *Longer*, will *Equiponderate*; And yet both the *Scales* being *empty*, ſhall be in *Æquilibrio*, as in the Figure.

Sup-




Suppose AC to have *eleven* such Parts, whereof AB hath but *ten*; and yet both of them (in themselves) of equal Weight: It is certain, that whether the *Scales* be empty, or whether in the *Scale* D we put 11 Pounds, and in E 10 Pounds, yet both of them shall *Equiponderate*, because there is just such a disproportion in the *length* of the *Sides*; AC being unto AB, as 11 is to 10.

How such deceitful *Ballances* may be discovered, is by changing the *Weights* into each other *scale*, and then the inequality will be obvious.

From these *Principles* here delivered, it is easie to conceive how a Man may find out the just Proportion of a *Weight*, which in any Point given, shall *equiponderate* to several *Weights* given, hanging in several places of the *Beam*.

Of these *Ballances*, some of them are so exactly made, (especially those that are in the *Say-Office* in the *Tower*, and at the *Goldsmiths Hall*,) as to be sensibly turned with the Eightieth part of a Grain. And *Capellus*, in his Book *De Ponderibus & Nummis*, mentions one at *Sedan*, that would turn with the Four hundredth part of a Grain.

## Certain THEOREMS of Mr. *Michael Dary's*, concerning the *Construction* and *Use* of the SCALE of PONDEROSITY, (commonly called) the STILLYARD.

I. *A Right-Line resting upon a Fulciment Equiponderate being proposed :*

Then,

If any *Ponderosity* shall be applied to a *Point* of *Pondency* in that *Line*, it ought to be understood, That that *Ponderosity* is transplanted from the *Fulciment*, to that Point of *Pendency*: But if any *Ponderosity* shall be

 with-

withdrawn, or taken away, from a *Point* of *Pendency* in that *Line*, it ought to be understood, That that *Ponderosity* is transplanted from the *Point* of *Pendency*, to the *Fulciment*.

II. *A Right-Line resting on a Fulciment Equiponderate being proposed:*

Then,

If divers *Ponderosities* shall be *pendently* applied on sundry *Points* of that *Line*, so that the said *Line* be *Equiponderate* again; then the *Facts* (of each *Ponderosity*, by its transplantation from the *Fulciment*) on this side the *Fulciment*, are equal to the *Facts* on that side the *Fulciment*.

III. *A Right-Line resting on a Fulciment Equiponderate by divers Ponderosities, pendent in several Points of that Line, being proposed:*

Then,

If *two* of the *Ponderosities Pendent* shall be transplanted, so that the said *Line* shall be *Equiponderate* again; then the *Facts* of each *Ponderosity* by his *distance* run in transplantation, are *equal*.

IV. *If a* Stillyard, *or Scale of Ponderosity, or (as the* Dutch *call it)* The Roman Beam, *be true* (i. e. *doth give the Truth*) *in two Points, (the farther distant, the better.)*

Then,

It is *true* in all the *Points* of *Pendency* throughout, the *Divisions* being *equal*.

## *Unto what Uses these Ballances may be applied.*

THere are several Contrivances to make use of these Ballances; as,

In measuring of the
- Weight of *Blows*.
- Force of *Powder*.
- Strength of *Strings*.
- Condenced *Air*.
- Distinct Proportion of several *Metals* mix'd together.
- Different Gravity of divers *Bodies* in the *Water*, from what they have in the open *Air*.

With divers the like Ingenious *Enquiries*.

CHAP.

## CHAP. III.

*Of the* Ballance *of Signeur* Galileo Galilei. *In which, in Imitation of* Archimedes *in the Problem of the* Crown, *he sheweth how to find the Proportion of the* Alloy *of* mix'd Metals; *with the manner how the same Instrument is to be made. With some Annotations of* Dominico Montovani *upon the said* Ballance.

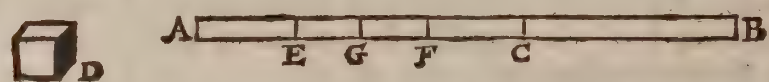
As it is well known, by such as take the pains to Read Old Authors. That *Archimides* detected the Cheat of the Goldsmith in the Crown of *Heron*, King of *Sicily*, and Kinsman to that great Mathematician *Archimedes*; so I think it hitherto unknown what Method this great Philosopher observed in that Discovery.

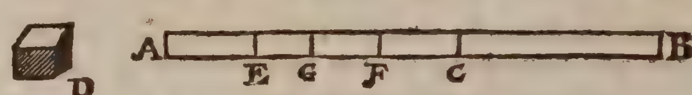
For the Opinion that he did perform it, by putting the Crown into the Water, having first put into it such another Mass of *Pure Gold*, and another of *Silver* severally, and that from the *differences* in their making the Water more, or less rise and run over, he came to know the *mixture*, or *Alloy* of the *Gold* with the *Silver*, of which that *Crown* was compounded; seems a thing (if I may speak it) very *Gross*, and far from Exactness. And it will seem so much the more dull, to such who have read and understood the exquisite Inventions of so Divine a Man, amongst the Memorials that are extant of him; by which it is very manifest, that all other Wits are inferior to that of *Archimedes*. Indeed I believe, that Fame divulging it abroad, that *Archimedes* had discovered that same Fraud by means of the Water, some Writer of those Times committed the Memory thereof to Posterity; and that this Person, that he might add something to that little which he had heard by common Fame, did relate, that *Archimedes* had made use of the Water in that manner, as since hath been, by the generality of Men, believed.

But in regard I know that that Method is altogether Fallacious, and falls short of that Exactness which is required in *Mathematical Matters*, I have often thought in what manner, by help of the Water, one might exactly find the *mixture* of two *Metals*; and in the end, after I had diligently perused that which *Archimedes* demonstrates in his Book *De insidentibus Aquæ*, and those others *De Æquiponderantium*; there came into my Thoughts a *Rule* which exquisitely resolveth our *Question*; which *Rule* I believe to be the same that *Archimedes* made use of; seeing, that besides the use that is to be made of Water, the exactness of the Work dependeth also upon certain *Demonstrations* found by the same *Archimedes*.

The way is by help of a *Ballance*, whose *Construction* and *Use* shall be shewn by and by, after we shall have declared what is necessary for the knowledge thereof. You must know therefore, that the Solid Bodies that sink in the Water, weigh so much Less in the Water than

than in the Air, as a Maſs of Water equal to the ſaid Solid, doth weigh in the Air; which hath been by *Archimedes* Demonſtrated. But, in regard his Demonſtration is very mediate, becauſe I would not be over long; laying it aſide, I ſhall declare the ſame another way. Let us conſider therefore, that putting into the Water, *v. g.* a *Maſs of Gold*, if that Maſs were of Water, it would have no weight at all; for the Water moveth neither upwards nor downwards in the Water: It remains therefore, that the Maſs of Gold weigheth in the Water only ſo much, as the *Gravity* of the Gold exceeds the *Gravity* of the Water. And the like is to be underſtood of other Metals. And becauſe that Metals are different from each other in Gravity, their Gravity in the Water ſhall diminiſh according to ſeveral Proportions. As for *Example:* Let us ſuppoſe that *Gold* weigheth twenty times more than *Water*, it is manifeſt by that which hath been ſpoken, that the *Gold* will weigh leſs in the *Water* than in the *Air*, by a *Twentieth* part of its whole Weight. Now, let us ſuppoſe that *Silver*, as being leſs grave than *Gold*, weigheth *Twelve* times more than *Water*; this then weighed in the Water, ſhall diminiſh in Gravity the *Twelfth* part of the whole Weight: Therefore, the *Gravity* of *Gold* in the Water, decreaſeth leſs than that of *Silver*; for that diminiſheth a *Twentieth* part, and that a *Twelfth.* If therefore, in an exquiſite *Ballance*, we ſhall hang a *Metal* at the one *Arm*, and at the other end a *Counter-poiſe*, that weigheth equally with the ſaid Metal in the Water, leaving the Counter-poiſe in the *Air*, to the end it may equivalate and compenſate the *Metal*, it will be neceſſary to hang it nearer the Perpendicular or Cock.




*Example.* Let the Ballance be A B, its Perpendicular C, and let a Maſs of ſome Metal be ſuſpended at B, counter-poiſed by the Weight D: Putting the Weight B into the Water, the Weight D in A would weigh more; therefore, that they may weigh equally, it would be neceſſary to hang it nearer to the Perpendicular C; as *v. g.* in E; and look how many times the Diſtance C A ſhall contain A E, ſo many times ſhall the Metal weigh more than the Water. Let us therefore ſuppoſe, that the Weight in B be *Gold*, and that weighed in the Water, it withdraws the Counterpoiſe D into E: And then doing the ſame with pure *Silver*, let us ſuppoſe that its Counterpoiſe, when afterwards it is weighed in the Water, returneth to F, which Point ſhall be nearer to the Point C, as Experience ſheweth, becauſe the *Silver* is leſs *Grave* than the *Gold*: And the Diſtance that is between A and F, ſhall have the ſame difference with the Diſtance A F, that the Gravity of the Gold hath with that of the Silver.

But

But if we have a mixture of *Gold* and *Silver*, it is clear, that by reaſon it participates of *Silver*, it ſhall weigh Leſs than the *Pure Gold*; and by reaſon it participates of *Gold*, it ſhall weigh more than the pure *Silver*; and therefore being weighed in the *Air*, and deſiring that the ſame Counterpoiſe ſhould Counterpoiſe it, when that Mixture ſhall be put into the Water, it will be neceſſary to draw that Counter-poiſe more towards the Perpendicular C, than the point E is; which is the Term of the *Gold*; and more from C than F is, which is the Term of the pure *Silver*: Therefore it ſhall fall between the points E and F; and the Proportion into which the diſtance E F ſhall be divided, ſhall exactly give the Proportion of the two *Metals* which compound that *Mixture.*

As for *Example*; Let us ſuppoſe the Mixture of *Gold* and *Silver* to be in B, Counterpoiſed in the Air by D, in the undermoſt Figure which Counterpoiſe, when the Compound Metal is put into the Water, returneth unto G: I ſay now, that the *Gold* and the *Silver* which compound this *Mixture*, are to one another in the ſame Proportion, as the diſtance F G is to the diſtance G E. But you muſt know, that the diſtance G F terminated in the Mark of the *Silver*, ſhall denote unto us the quantity of the *Gold*; and the diſtance G E, terminated in the Mark of the *Gold*, ſhall ſhew us the quantity of the *Silver*: Inſomuch, that if F G ſhall prove double to G E, then that Mixture ſhall be *two* parts *Gold*, and *one* part *Silver*: And in the ſame Method proceeding in the Examination of other *Mixtures*, one ſhall exactly find the quantity of the ſimple *Metals.*

### *The Compoſition of the* Ballance.

To Compoſe the *Ballance*, therefore, Take a *Rod*, at leaſt a Yard long (and the longer it is, the exacter the *Inſtrument* ſhall be) and divide it in the midſt, where place the *Perpendicular*; then adjuſt the *Arms*, that they may ſtand in *Equilibrium*, by Filing, or Shaving that leſs, which weigheth moſt; and upon one of the *Arms*, Note the *Terms* to which the *Counterpoiſes* of ſimple *Metals* return, when they ſhall be weighed in the *Water*; taking care to weigh the pureſt *Metals* that can be found, this being done, it remaineth that we find out a way, how we may with facility diſcover the proportion, according to which the diſtances between the *Terms* of the *ſimple* and *pure Metals* are divided by the *marks* of the *mixt Metals*; which ſhall be effected in this manner.

We are to have two very ſmall *Wiers* drawn thorough the ſame *drawing Iron*, one of *Steel*, the other of *Braſs*, and above the Terms of the *ſimple Metals* we muſt wind the *Steel Wire*; as for Example; Above the point E, the Term of the *pure Gold*, we are to wind the *Steel Wire*, and under it the other *Braſs Wire*; and having made *Ten* folds of the *Steel Wire*, we muſt make *Ten* more with that of *Braſs*; and thus we are to continue to do with *Ten* of *Steel*, and *Ten* of *Braſs*, until that the whole ſpace between the points E and F, the *Terms* of the *Pure Metals*, be full; cauſing thoſe two *Terms* to be always viſible and perſpicuous: And thus the diſtance E F ſhall be divided into many

many equal parts, and numbered by *Ten* and *Ten*. And if at any time we would know the *Proportion* that is between F G and G E, we must count the *Wires* F G, and the *Wires* G E; and finding the *Wires* F G to be, for *Example*, 40, and the *Wires* G E 21: We will say, That there is in the *mixt Metal* 40 parts of *Gold*, and 21 of *Silver*. But here you must note, that there is some difficulty in the counting; for those *Wires* being very small, as it is requisite for exactness sake, it is not possible with the Eye to tell them, because the smallness of the spaces dazeleth and confoundeth the Sight: Therefore, to number them with facility; take a *Bodkin* as sharp as a *Needle*, and set it into a *Handle*, or a very fine pointed *Pen-knife*, with which we may easily run over all the said *Wires*; and this way, partly by help of *hearing*, partly by the *impediments* the *Hand* shall feel at every *Wire*, those *Wires* shall be counted; the Number of which, as I said before, shall give us the exact quantity of the *simple Metals* of which the *mixt Metal* is Compounded; taking Notice that the *simple* answer alternately to the *Distances*. As for Example, in a *mixture* of *Gold* and *Silver*; the *Wires* that shall be towards the *Term* of *Gold*, shall shew us the quantity of the *Silver*; and the same is to be understood of other *Metals*.

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## CHAP. IV.

*Six* Theorems, *extracted out of* Archimedes *his Tract*; *Entituled*, De Incidentibus Aqua: *Very necessary for the better understanding of several Statical Experiments and Conclusions herein contained.*

### THEOREM I.

THE *Superficies* of every *Liquid*, that is consistant and [settled,] shall be of a *Spherical* Figure, which *Figure* shall have the same *Center* with that of the *Globe* of the whole *Earth* and *Waters*.

### THEOREM II.

SOlid *Magnitudes* that being of equal *Mass* with the *Liquid*, are also *Equal* to it in *Gravity*, being demitted into the [settled] *Liquid*, do so submerge in the same, as that they lie, or appear not at all above the *Surface* of the *Liquid*, nor yet do they *Sink* to the Bottom.

THEOREM

THEOREM III.

SOlid *Magnitudes* that are *Lighter* than the *Liquid*, being demitted into the [ſettled] *Liquid*, will not totally *Submerge* in the ſame; but ſome part thereof will lie, or ſtay, above the *Surface* of the *Liquid*.

THEOREM IV.

SOlid *Magnitudes* that are *Lighter* than the *Liquid*, being demitted into the [ſettled] *Liquid*, will ſo far Submerge, till that a *Maſs* of *Liquor*, equal to the *Part* Submerged, do in *Gravity* equalize the whole *Magnitude*.

THEOREM V.

SOlid *Magnitudes Lighter* than the *Liquid*, being thruſt into the *Liquid*, are repulſed upwards with a *Force*, as great as is the exceſs of the *Gravity* of a *Maſs* of *Liquor* equal to the *Magnitude*, above the *Gravity* of the ſaid *Magnitude*.

THEOREM VI.

SOlid *Magnitudes*, *Heavier* than the *Liquid*, being demitted into the [ſettled] *Liquid*, are born downwards as far as they can deſcend; and ſhall be *Lighter* in the *Liquid*, by the *Gravity* of a *Liquid Maſs* of the ſame *Bigneſs* with the *Solid Magnitude*.

*Here followeth ſome other* Theorems *of Mr.* William Oughtred *concerning this matter.*

THEOREM I.

IF four Pieces of *Metals*, whereof the *Third* is of the ſame kind with the *Firſt*; and the *Fourth* of the ſame kind with the *Second*, are proportional: Their *Gravities* [or *Weights*] ſhall be Proportional.

THEOREM II.

IF there be four Pieces of *Metal*, whereof the *Third* is of the ſame kind with the *Firſt*; and the *Fourth* of the ſame kind with the *Second*; and the *Firſt* and *Second* be of *equal Greatneſs*; and the *Third* and *Fourth* of equal *Weight*: The *Weight* of the *Firſt* and *Second* ſhall be reciprocally Proportional to the *Magnitudes* of the *Third* and *Fourth*.

### Theorem III.

If *Spheres* of the ſame *Matter*, are in *Gravity*, or *Weight*, as the *Cubes* of their *Diameters* are in *Magnitude. Et contra.*

### Theorem IV.

Pieces of *Metal*, if they be of equal *Magnitude*, have their *Weights* in *Direct Proportion*, as is ſet down in the following Table: But if they be of equal *Weight*; they have their *Magnitudes* in Reciprocal Proportion.

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## CHAP V.

### *Concerning the Compariſon of ſeveral* Metals *in* Quantity *and* Weight.

Concerning this matter, I will give you the Proportions or Compariſons of the moſt Principal kinds of *Metals* in common Uſe; Namely of *Gold* ☉; *Quick-Silver* ☿; *Lead* ♄; *Silver* ☾; *Braſs* ♀; *Iron* ♂; *Tin* ♃; according to the Experiments and Obſervations of *Marinus Ghetaldus*, in his forementioned Book; Entituled, *Archimedes Promotus*; as followeth, *Viz.*

| | | | |
|---|---|---|---|
| ☉ Gold | 3990 | ♀ Braſs | 1890 |
| ☿ Quick-Silver | 2850 | ♂ Iron | 1680 |
| ♄ Lead | 2415 | ♃ Tin | 1554 |
| ☾ Silver | 2170 | | |

Wherefore,

| | | | | | | |
|---|---|---|---|---|---|---|
| ☉ Gold, hath ſuch Proportion to | ☿ Quick Silver | As | 7 | Hath to | 5 | Or in Decimals, as 3990 to 2850 |
| | ♄ Lead | | 38 | | 23 | 2415 |
| | ☾ Silver | | 57 | | 31 | 2170 |
| | ♀ Braſs | | 19 | | 9 | 1890 |
| | ♂ Iron | | 19 | | 8 | 1680 |
| | ♃ Tin | | 95 | | 37 | 1554 |

Which Numbers Mr. *Gunter* in the 5th Chap. of his 3d Book of the *Sector* hath expreſſed in the ſame Terms, and that in whole Numbers by changing the *Vulgar Fractions* of theſe Numbers into *Decimals*, putting the firſt Number 10000, whereas *Ghetaldus* puts it but 100; which Fractions Dr. *Wyband* in his *Tactometria* Pag. 201. hath put into a Table, both in *Direct* and *Reciprocal* Proportion; in reſpect of the *Equal Magnitudes* and *Gravities* of like Bodies of different Metals.

Pro-

| Proportion Direct. | | | Reciprocal Proportion. | | |
|---|---|---|---|---|---|
| In like Bodies of several Metals and equal Magnitude: Having the weight of the one, to find the weight of the other. | ☉ Gold | 10000 | 3895 | Gold ☉ | In like Bodies of several Metals and equal weights, having the Magnitude of the one, to find the Magnitude of the rest. *The Converse of the former.* |
| | ☿ Quick Sil. | 7143 | 5453 | Quick Sil. ☿ | |
| | ♄ Lead | 6053 | 6435 | Lead ♄ | |
| | ☾ Silver | 5439 | 7161 | Silver ☾ | |
| | ♀ Brass | 4737 | 8222 | Brass ♀ | |
| | ♂ Iron | 4210 | 9250 | Iron ♂ | |
| | ♃ Tin | 3895 | 10000 | Tin ♃ | |

Mr. *William Oughtred* in the 10th *Chapter* of his *Circles of Proportion*, says, that *Ghetaldus* useth the *Ancient Roman Foot*, which by the Measure set down in his Book seemeth to be very little less than our usual *English Foot*, if not exactly the same. But, concerning this matter, let us make farther scrutiny.

# CHAP. VI.

## *The Roman and English Foot Compared.*

FOR farther Enquiry into this Matter, Mr. *John Graves*, in his Treatise of the *Roman Foot*, hath deduced from divers Observations and Experiments, by him made, with great Pains and Industry in his Travels, (especially in *Italy* and there at *Rome*,) more clearly expresses the *Dimension* or *Magnitude* of the *True Roman Foot*, not only *Linearly*, but also *Numerally*; in comparing it with the *Standard Measures* of *England*, and divers other *Nations*.

### *Of the several sorts of Roman Feet.*

There are (as the above named Mr. *Graves* relates) several sorts of *Ran Feet*, used by divers Authors; amongst which, that which *Ghetaldus* made use of was this next following.

1. *Pes Colotianus*, to be found *in Hortis Colotianis* in *Rome*: Which Foot, he comparing with our English Foot, findeth, that it containeth 967 such Parts, as our English Foot doth 1000: And so our English Foot to contain 1034. 13 such Feet, as the said *Pes Colotianus* (or Roman Foot) contain'd 1000: Whereby this Roman Foot should be exactly 11. 604 such Parts, as our English Foot is 12, *Viz.* 11. 604 Inches, wanting of our English Foot only 0. 396 Inches.

2. There is another *Roman Foot* mentioned by the ſame Mr. *Graves*, which is that on the Monument of *Statilius*, In *Hortis Vaticanis* in *Rome*, which comes ſomewhat nearer to our Engliſh Foot than the former, for he obſerved it to be 972 ſuch parts, as the Engliſh Foot is 1000 (and to be 1005. 17 of the *Pes Colotianus*, being 1000) whereby this Foot will be 11. 7 *ferè* of the Engliſh Foot, being 12, *Viz.* 11. 66 Inches; which wanteth only 0. 34 Inches of the Engliſh Foot.

3. A Third Roman Foot mentioned by him, is that of *Villalpandus*, deduced from the *Congius* of *Veſpaſian* in *Rome*, which he ſaith to be 986 parts of our Engliſh Foot, containing 1000. (and 1019. 65 of *Pes Colotianus*, being 1000) and ſo is 11. 8 of the Engliſh Foot being 12, *viz.* 11.8 Inches; which wants of the whole Engliſh Foot, only 0.2 Inches.

4. But the Ancient *Greek Foot*, doth (by his Obſervation) more nearly agree with our Engliſh Foot, than this laſt Roman Foot, being (by his Collation) 1007.29, of which the Engliſh Foot is 1000, which is hardly .09 parts of an Inch above a Foot Engliſh, it being 12.087 Inches Engliſh.

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## CHAP. VII.

### *Of Weights: And the Ancient Roman, and our Engliſh Weights compared.*

As for the *Weights* uſed by *Ghetaldus*, they are ſurely the *Roman Weights*, for he ſaith, they were the *Weights* uſed in his time, and thoſe *Weights* have continued the ſame for many Ages. And Mr. *Graves* in his Diſcourſe of the *Denarius*, puts this as an undeniable *Principle* and *Foundation*, from whence the *Weights* of the *Ancients* may be deduced [as the *Roman Foot* for the *Principle* of their *Meaſures*] having Collated with the *Troy Weights* from our *Engliſh Standard* for *Gold* and *Silver*, by *Grains* thereof ſaith; That the *Roman Pound*, both *Ancient* and *Modern*, containeth 5256 ſuch *Grains*: And ſo the *Roman Ounce* both *Ancient* and *Modern*, 438 of the ſame *Grains*; the *Troy Pound* containing 5760 *Grains*; and ſo the *Troy Ounce* 480: Whereupon the *Roman Pound* and *Ounce* ſhould be (in the leaſt Terms) but $\frac{73}{80}$ of our *Engliſh Pound* and *Ounce Troy*. And ſo the Proportion of the *Roman Pound* and *Ounce*, to our *Troy Pound* and *Ounce*, as 80 to 73: Or in *Decimals*, as 10000 to 9125. And this is the commonly received proportion of the *Ounce Averdupois* to the *Ounce Troy*; and the contrary.

Moreover,

The *Pound* and *Ounce* uſed by *Mar. Ghetaldus* in his Book, Entituled, *Archimedes Promotus*, being compared with our *Engliſh Pound* and *Ounce Troy*, have ſuch proportion as followeth; *Viz.*

One $\left\{\begin{matrix}\text{Ounce}\\\text{Pound}\end{matrix}\right\}$ Of *Ghetaldus* Weight contains $\left\{\begin{matrix}576\\6912\end{matrix}\right\}$ Grains.

And

And

| | | | | |
|---|---|---|---|---|
| One | Ounce / Pound | Of our *Troy Weight* contains. | 480 / 5760 | Grains |

*Which Reduced to the least Terms, is, As* 10 *To* 12.

And then,

*As* 10,
*Is* to 12 *:*
*So* is 480 Grains, or one Ounce or Pound of English *Troy Weight*,
*To* 576 Grains, or one Ounce or Pound of *Ghetaldus* Weight.

*Other Observations.*

There is at this time in the Tower of *London*, (which hath been there ever since the Reign of K. *Henry* the VII.) in a Velvet Case; an exact Cube of fine Iron, which by the Standard Ballance, there was found to Weigh of Troy Weight 4 Ounces, 3 Peny-Weight, 9.12 Grains.

And from hence by Experiment there made; one Cubick Inch of Cast Iron will weigh 3.968 Ounces Troy, or 0.33068 Pound Troy.

And from hence,

A Sphere or Bullet of one Inch Diameter, of fine Forged Iron will weigh 2.18288 Ounces Troy, or 0.1819 Parts of a Pound Troy Weight.

And,

A Sphere or Bullet of 4 Inches Diameter, made of the same fine Forged Iron, will weigh 11.642 Pound, or 11 Pound 6 Ounces 2 Peny Weight, and 20 Grains Troy.

Also,

| | | | | |
|---|---|---|---|---|
| A Sphere of 1 Inch Diameter of | Gold | Will weigh of Troy Weight | 2625.6 | Grains. |
| | Silver | | 1427.95 | |
| | Tin | | 1022.6 | |

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## CHAP. VIII.

### *The Weight of* Spheres *of several* Metals *compared together.*

AS For the Weights of *Metals* compared in *Spheres* of one and the same *Magnitude* in *Troy Weight* (wherein also are Observed the foresaid common proportions between *Troy* and *Averdupois* Weights) they are according to the Experiments of *Ghetaldus*, being deduced from his Comparitive Numbers, into the Parts of

*Troy*

*Troy Weight*, and by him inſerted into a *Table*; though not very preciſely: Which Table Dr. *Wybard* in his *Tactometria* Pag. 237, hath put moſt Correct and Exact, and in *Grains* and Milleſimal parts of a *Grain*: He ſuppoſing firſt (with *Ghetaldus*) a *Sphere* of *Gold* to weigh juſt one Pound *Troy*: And from thence the other *Metalline Spheres* of the ſame *Magnitude* to Weigh accordingly.

The TABLE.

| | Ounc | Pen. W. | Grain | Min. | Grains. Parts. |
|---|---|---|---|---|---|
| ☉ Gold | 12 | 00 | 00 | 00 | 5760.00 |
| ☿ Quick Sil. | 8 | 11 | 10 | 6 *fere* | 4114.285 |
| ♄ Lead | 7 | 5 | 6 | 6 | 3486.316 *fere* |
| ☾ Silver | 6 | 10 | 12 | 12 | 3132.631 |
| ♀ Braſs | 5 | 13 | 16 | 8 | 2728.421 |
| ♂ Iron | 5 | 1 | 1 | 7 | 2425.294 |
| ♃ Tin | 4 | 13 | 11 | 5 | 2243.368 |

# CHAP. IX.

## *Some Obſervations concerning the Worth, Weight, Magnitude, &c. of ſeveral Metals, and other Liquids.*

### I. *Of* GOLD.

GOLD ſurpaſſeth all other Metals in theſe Reſpects, *(1.)* Greatneſs of Weight. (2.) Cloſeneſs of Parts. (3.) Fixation. (4.) Pliantneſs or Softneſs. (5.) Immunity from Ruſt. *(6.)* Colour or Tincture of yellow.

*The Worth of* Gold.

| | | | *l.* | *s.* | *d.* | *q.* |
|---|---|---|---|---|---|---|
| One | Pound Weight | *Troy* is worth | 40 | 0 | 0 | 0 |
| | Ounce | | 3 | 6 | 8 | 0 |
| | Peny Weight | | 0 | 3 | 4 | 0 |
| | Grain | | 0 | 0 | 1 | 2 |

This is the Price of ordinary Gold: Angel Gold is worth ſomewhat more; And Sovereign Gold ſomewhat leſs.

*The*

*The Worth of* Silver.

| | | | *l.* | *s.* | *d.* | *q.* |
|---|---|---|---|---|---|---|
| One | Pound Weight | *Troy* is worth | 3 | 0 | 0 | 0 |
| | Ounce | | 0 | 5 | 0 | 0 |
| | Peny Weight | | 0 | 0 | 3 | 0 |
| | Grain | | 0 | 0 | 0 | 0½ |

But of *English Coin*,

| | | | *l.* | *s.* | *d.* | *q.* |
|---|---|---|---|---|---|---|
| Of | Gold | One Pound of *Troy* Weight is worth | 40 | 18 | 4 | 3 |
| | Silver | | 3 | 2 | 0 | 0 |

And by the foregoing Proportions.

| | | | *l.* | *s.* | *d.* | *q.* |
|---|---|---|---|---|---|---|
| Of | Gold | One Pound Weight *Averdupois* is worth | 49 | 13 | 8 | 1 |
| | Silver | | 3 | 15 | 3 | 2 |

## CHAP. X.

### *Of the Weight of Water, and other things, in Weight and Magnitude.*

| | | | | |
|---|---|---|---|---|
| One Ounce | *Troy* | of Water contains | 1.8949 | Inches. |
| | *Averdupois* | | 1.72556 | |
| One Ounce | *Troy* | of Water contains | 0.001096 | Feet. |
| | *Averdupois* | | 0.00099859 | |
| One Pound | *Troy* | of Water is of solid Measure | 22.7368 | Inches. |
| | *Averdupois* | | 27.609 | |
| One Pound | *Troy* | of Water is of solid Measure | 0.013158 | Foot. |
| | *Averdupois* | | 0.115917 | |

A Cubical Foot of Water weigheth of *Troy*-Weight 912 Ounces; which is 76 *l. Troy.* And,

A Cubical Foot of Water weigheth of *Averdupois*-Weight 999.463 Ounces; which is 62.588 *l.* That is, 62 *l.* 9 Ounces, 6 Drams and a half.

From those Proportions, divers *Statical* Experiments may be made by weighing several Metals, and other things, in the Water, and in the Air; The Measuring of Irregular Bodies, either in whole or in part, *&c.*—— And although there may be some difference in the Weight of several Waters, as Rain-Water, River-Water, Fountain and Spring Water;

Water, &c. yet the greateſt difference that Dr. *Wybard* could find, was, but as 1.000000 to 1.002104, which is little above 2 in 1000.

Yet the difference which *Snellius* makes between the Gravity of Rain-water and others, is 1.000000 to 1.007522; but Dr. *John Wybard* makes it but as 1.000000 to 1.002104, which is little above $\frac{2}{1000}$, or 2 in a thouſand. Which latter Proportion I do rather adhere unto, for that (to my own knowledge) the aboveſaid Dr. *Wybard* made this following Experiment, *viz.* He cauſed a Glaſs to be blown on purpoſe which held about five and a half Wine-Pints, which he filled with clean Rain-water, which had ſettled ſome days, and filling the Glaſs therewith, he weighed it in a Standard Ballance in the Tower of *London* (or at Goldſmiths-Hall, I remember not well which) which would turn at the weight of one Grain, and he found the differences of the Weights of theſe ſeveral Waters from Rain-water to be as followeth, *viz.* in the aboveſaid Quantity of five Pints and a half.

1. Snow-water he found to be lighter than Rain-water by 8 Grains.
2. *Thames*-water, and *Middleton*'s New-River-water, to be Equal in Weight with Rain-water.
3. *Cheapſide*-Conduit-water to be heavier than Rain-water by 14 Grains.
4. *Lambs*-Conduit-water in *Grays-Inn-Fields* to be heavier than Rain-water by one Peny-weight, or 24 Grains.
5. The Water at the Poſtern-Spring upon the *Tower-hill* heavier than Rain-water by 57 Grains. And,
6. *Crowders*-Well-water, by *Cripplegate*-Church, he found to weigh in the ſame Quantity 84 Grains.

Unto the foregoing Proportions, I ſhall here inſert a Table not long ſince Publiſhed by Sir *Jonas Moor*.

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A TA-

A TABLE comparing the Weight of Metals, Stones, Grains, Liquors, &c.

| *The Names of the Metals, &c.* | *The Weight of a Cubick Inch in Magnitude in Troy Weight.* | *The Magnitude in Inches and D. parts, answ. to one Ounce of Troy W.* | *The Weight of a Cubick Inch in the Water in Troy Ounc. Dec. parts.* |
|---|---|---|---|
| | Oun. Parts. | Inch. Parts. | Oun. Parts. |
| ☉ Gold | 9.91735 | 0.10083 | 9.33962 |
| ☿ Quick-silver | 7.93388 | 0.12604 | 7.35615 |
| ♄ Lead | 6.16198 | 0.16229 | 5.58425 |
| ☾ Silver | 5.50083 | 0.18179 | 4.92310 |
| ♀ Copper | 4.81342 | 0.20776 | 4.23569 |
| ♂ Hammer'd-Iron | 4.27715 | 0.23380 | 3.69942 |
| Cast-Iron | 3.96821 | 0.25253 | 3.29048 |
| ♃ Tin | 3.96694 | 0.25208 | 3.38921 |
| Marble | 1.59631 | 0.62644 | 1.01858 |
| Common Stone | 1.09835 | 0.91045 | 0.52062 |
| Honey | 0.79339 | 1.26042 | 0.21566 |
| Salt Water | 0.57773 | 1.79490 | 0.00000 |
| Fresh Water and Wine | 0.52773 | 1.77190 | |
| Oil | 0.47603 | 2.10069 | |
| Wheat | 0.37628 | 2.65757 | |
| Dried Oak | 0.40745 | 2.45609 | |

A TABLE of Foreign Weights and Measures compared with the *English*. By Sir *Jonas Moore*.

| *Names of Places.* | *The* English *Foot divided into* 1000 *equal parts.* | *The* English *Foot divided into Inches, and* 10*th parts of an Inch.* | *The Pound* Averdupois *divided into* 100 *parts.* |
|---|---|---|---|
| *ENGLAND.* | | | |
| London Foot | 1000 | 0.12.0 | 100 |
| *FRANCE.* | | | |
| Paris Royal Foot | 1.068 | 1.00.8 | 0.93 |
| Lyons Ell | 3.976 | 3.11.7 | 1.09 |
| Boloyn Ell | 2.076 | 2.00.8 | 0.89 |
| XVII. *PROVINCES.* | | | |
| Amsterdam Foot | .942 | 0.11.3 | 0.93 |
| Amsterdam Ell | 2.269 | 2.03.2 | |
| Antwerp Foot | .946 | 0.11.3 | 0.98 |
| Antwerp Ell | 2.278 | 2.03.3 | |
| Brill Foot | 1.130 | 1.01.2 | |
| Dort Foot | 1.184 | 1.02.2 | |
| Rynland, *or* Leyden Foot | 1.033 | 1.00.4 | 0.96 |
| Rynland, *or* Leyden Ell | 2.260 | 2.03.1 | |
| Lorrain Foot | .958 | 0.11.4 | 0.98 |
| Mechalin Foot | .919 | 0.11.0 | 0.98 |
| Middleborough Foot | .991 | 0.11.9 | 0.98 |
| *GERMANY.* | | | |
| Strasborough Foot | .920 | 0.11.0 | 0.93 |
| Bremes Foot | .964 | 0.11.6 | 0.94 |
| Cologn Foot | .954 | 0.11.4 | 0.97 |
| Frankford ad Menam Foot | .948 | 0.11.4 | 0.93 |
| Frankford ad Menam Ell | 1.826 | 1.09.9 | |
| Hamborough Ell | 1.905 | 1.10.8 | 0.95 |
| Leipsig Ell | 2.260 | 2.03.1 | 1.17 |
| Lubick Ell | 1.903 | 1.09 8 | |
| Noremberg Foot | 1.006 | 1.00.1 | 0.94 |
| Noremberg Ell | 2.227 | 2.03.3 | |
| Bavaria Foot | .954 | 0.11.4 | |
| Vienna Foot | 1.053 | 1.00.6 | 0.83 |
| *SPAIN* and *PORTUGAL.* | | | |
| Spanish Palm, *or* Palm *of* Castile | .751 | 0.09.0 | 0.99 |
| Spanish Vare, *or* Rod, 4 Palms | 3.004 | 3.00.0 | |

*Names*

| *Names of Places.* | *The* English *Foot divided into* 1000 *equal parts.* | *The* English *Foot divided into Inches, and* 10*th parts of an Inch.* | *The Pound* Averdupois *divided into* 100 *parts.* |
|---|---|---|---|
| Their Foot is one Third of the Vare | 1.001 | 1.00.0 | |
| Lisbon Vare | 2.750 | 2.09.0 | 1.06 |
| Gibraltar Vare | 2.760 | 2.09.1 | 1.03 |
| Toledo Foot | .899 | 0.10.7 | 1.00 |
| Toledo Vare | 2.685 | 2.08.2 | |
| *ITALY.* | | | |
| Roman Foot *on the Monum. of* Cossutius | .967 | 0.11.6 | 1.23 |
| Roman Foot *on the Monum. of* Statillius | .972 | 0.11.7 | |
| Roman Palm for Building, whereof Ten make the Cauna | .732 | 0.08.8 | |
| Bononia Foot | 1.204 | 1.02.4 | 1.27 |
| Bononia Ell | 2.147 | 2.01.7 | |
| Bononia Perch, whereof 500 make a Mile | 12.040 | 12.00.5 | |
| Florence Brace *or* Ell | 1.913 | 1.11.0 | 1.23 |
| Naples Palm | .861 | 0.09.6 | 1.43 |
| Naples Brace | 2.100 | 2.01.2 | |
| Naples Cauna | 6.880 | 6.10.5 | |
| Genoa Palm | .830 | 0.09.6 | 1.42 |
| Mantoua Foot | 1.569 | 1.06.8 | 1.43 |
| Milan Calamus | 6.544 | 6.06.5 | 1.40 |
| Parma Cubit | 1.866 | 1.10.4 | 1.43 |
| Venice Foot | 1.162 | 1.01.9 | 1.53 |
| *Other Places.* | | | |
| Dantzick Foot | .944 | 0.11.3 | 1.19 |
| Dantzick Ell | 1.903 | 1.10.8 | |
| Copenhagen Foot | .965 | 0.11.6 | 0.94 |
| Prague *in* Bohemia Foot | 1.026 | 1.00.3 | 1.06 |
| Riga Foot | 1.831 | 1.09.9 | |
| China Cubit | 1.016 | 1.00.2 | |
| Turin Foot | 1.062 | 1.00.7 | |
| Cairo Cubit | 1.824 | 1.09.9 | 1.62 |
| Persian Arash | 3.197 | 3.02.3 | |
| Turkish Pike, at *Constantinople*, the greater | 2.200 | 2.02.4 | 0.86 |
| The Greek Foot | 1.007 | 1.00.1 | |
| The Universal Measure | 3.267 | 3.03.2 | |

*A Pendulum of the just length whereof will Vibrate 60 times in one Minute of Time.*

## CHAP. XI.

### *Experiments* STATICAL.

REgard being had to what hath been before delivered about the *Ballance*; and also concerning the *Weights* and *Measures* of *England*, and those of the *Romans* Ancient and Modern; as also the Proportions of the *Weights* of *Metals* and *Waters*; several *Experiments* may be deduced; some whereof follow.

### PROBL. I.

*If a* Sphere *of* Tin *of one Inch Diameter, do Weigh* 0.17753 *l.* Troy *Weight* (*or* 0.146285 *l. of* Averdupois *Weight*) as it hath been found so to do, by Dr. *Wybares* exact Experiment; *What shall a Sphere of* Tin *weigh, whose Diameter is* 7 *Inches.*

SPheres (and other *Regular Bodies*) are in Proportion one to another, as are the *Cubes* of their *Diameters*; VVherefore, Cube the Diameter given 7, it makes 343, which multiplyed by 0.17753 l. the Product will be 60.89279 for the VVeight of the Sphere of Tin, whose Diameter is 7 Inches.

Or, If the VVeight of the Bullet were required in *Averdupois* VVeight, then multiply 0.146285 (the proportional Number for *Averdupois* VVeight) by 343 (the Cube of 7, the Diameter,) the Product will be 50.175755 l. *Averdupois*. So that a Sphere of Tin of 7 Inches Diameter will weigh

| | | ℔. | *Oz.* | *P.wt.* | *Gr.* |
|---|---|---|---|---|---|
| Of *Troy* | VVeight | 60. | 10. | 14. | 16. |
| | | ℔. | *Oz.* | *Dr.* | |
| Of *Averdupois* | VVeight | 50. | 2. | 12. | $\frac{1}{4}$ |

### PROBL. II.

*If a Sphere of Tin do Weigh* 60.89279 *Pound, or* 1022.6 *Grains* Troy, *what shall the Diameter of that Sphere be?*

THE VVeight of a Sphere of Tin, whose Diameter is one Inch, was found to weigh 1022.6 Grains (as in *Chap.* VII.) which is 0.17753 Parts of a Pound *Troy*. Wherefore, divide 60.89279 ℔. by 0.17753 ℔. and the Quotient will be 343, whose Cube Root is 7, for the Diameter of a Sphere of Tin, which weigheth 60.89279 Pound.

PROBL.

## PROBL. III.

*Having the Weight and Diameter of a Sphere of one ſort of Metal given, to find the Length of the Diameter of a Sphere of the ſame Weight, of any other Metal; and alſo the Weight of a Sphere of the other Metal, whoſe Diameter ſhall be equal to the given Spheres Diameter.*

THere is a Sphere of Tin, whoſe Diameter is 7 Inches, and it weigheth 60.89279 ℔. *Troy*; what muſt the Diameter of a Sphere of Silver be that ſhall have the ſame VVeight.

I. *For the Diameter of the Silver Sphere, equal in Weight to the given Sphere.*

*As* 2170 (the Proportional Number for Silver,)
*Is* to 343 (the Cube of 7, the Diameter of the Sphere give)
*So* is 1554 (the Proportional Number for Tin)
*To* the Cube of the Diameter of the Silver Sphere;

Wherefore,

Multiply 1554, by 343, the Product will be 532022 which divided by 2170, gives in the Quotient 245.171; whoſe Cube Root is 6.228 Inches, and ſo much muſt the Diameter of a Silver Sphere be, that will Weigh 60.89279 Pounds *Troy*.

II. *For the Weight of the Silver Sphere, equal in Diameter to the Sphere given.*

*As* 1554 (the Proportional Number for Tin)
*Is* to 2170 (the Proportional Number for Silver)
*So* is the Weight of the Sphere of Tin 60.89279.
*To* the VVeight of the Sphere of Silver, 85.03054.

Multiply the given VVeight in Tin 60.89279, by 2170, the Product will be 132137.3543, which divided by 1554, the Quotient will be 85.03054, for the VVeight of a Sphere of Silver, whoſe Diameter is 7 Inches.

## PROBL. IV.

*Being an Experiment of a Marble Bullet VVeighed in the Air, and in the VVater, by Dr.* Wybard *in* Goldſmiths-Hall, *and Mr.* Jackſon *the Sea Maſter there.*

THey took a Marble Bullet, whoſe Diameter taken by a very fine pair of Calopers, they found to be 4.95 Inches; and ſo found the Solid Content to be 63.5 Inches, which Bullet VVeighed in the Air,

Air, they found to Weigh 89.10 Ounces *Troy*: And afterwards weighed in the Water, they found it to Weigh 55.75 Ounces, the Difference is 33.35 Ounces.

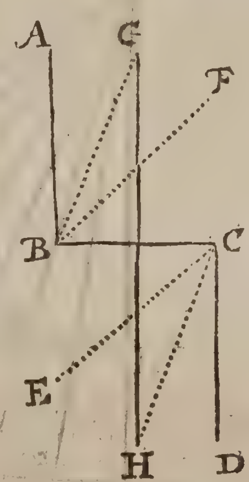
Now, one Ounce *Troy* of VVater is equal to 1.8949 Inches *Troy*; wherefore, divide 63.5 the solid Content in Inches, by 1.8949, the VVater equal to one Solid Inch, and the Quotient will be 33.51 equal to the Solidity.

In like manner, if an irregular Figure, or Statue of the like matter should VVeigh in the Air of *Averdupois* VVeight 231 ℔. And when VVeighed in the VVater, the Water overflowing, weighed 66 ℔. Now (by what hath been said before) one Pound *Averdupois* of VVater is equal to 27.609 Inches. VVherefore, divide 66.00000 ℔, by 27.609, the Quotient will be 2.390.

*The End of the Statical Part.*

# Poſtſcript.

*How is it, that a Man ſitting in a Chair, his Back to the back of the Chair, and his Legs by the fore frame of the Chair upon the Ground, cannot riſe off the Chair except he bend his Body forward, or put his Legs backwards.*




IN the Poſture of Sitting, our Legs are ſuppoſed to make a Right Angle with our Thighs, and they with our Backs: As in the Figure.

Wherein, Let A B repreſent the Back; B C the Thighs; and C D the Legs. It is now evident, That a Man cannot riſe from this Poſture, unleſs, either the Back A B, do firſt incline unto F, to make an acute Angle with the Thighs B C; or elſe that the Legs C D, do encline towards E, which may alſo make an acute Angle with the Thighs B C: Or, laſtly, unleſs both of them do decline to the Points G and H, where they may be included in the ſame Perpendicular.

For the reſolution of which, Philoſophers give theſe two Reaſons:

1. A Right Angle (ſay they) is a kind of Equality, and that being Naturally the cauſe of Reſt, muſt needs be an impediment to the motion of Riſing.

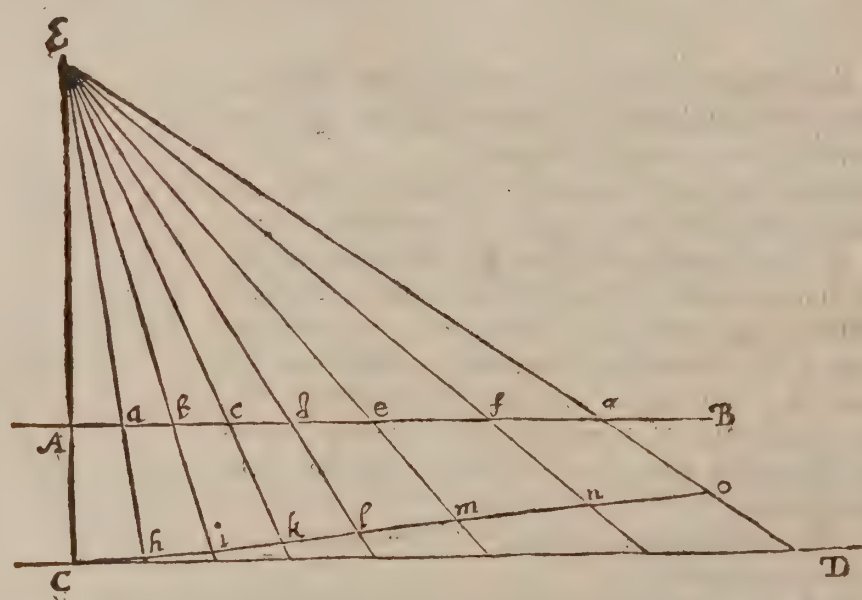
2. Becauſe, when either of the Parts are brought into an acute Angle, the Head being removed over the Feet, or they under the Head, in ſuch a Poſture the whole Man is much nearer diſpoſed to the form of ſtanding, wherein all theſe Parts are in one ſtreight Perpendicular Line, then he is by the other of Right Angles, in which Back and Legs are two Parallels; or that of turning theſe Right Angles into Obtuſe, which would not make an erect Poſture, but declining rather.

Theſe are the Philoſophical Reaſons; the Geometrical may be theſe. Suppoſe B C to be a Leaver, towards the middle of which is the place of the Fulciment, Prop or Center, A B as the Weight, and C D, the Power which is to raiſe it.

Now the Body being ſituate in this Rectangular Form, the Weight A B muſt needs be augmented proportionably to its diſtance from the Center, which is about the middle of the Thighs; whereas, if we ſuppoſe either the Weight to be inclined unto F, or the Power C D to E, or both of them to G and H, then there is nothing to be lifted up but the bare Weight it ſelf, which in this ſituation is not at all increaſed with any Addition by diſtance.

How

*How upon a Plain Superficies, a Right Line being drawn; to draw another Line, which ſhall incline more towards that Right Line, yet never concur or meet with it in any part.*




THis ſeems to be againſt the Definition of Parallels; but you are to note the Line to be thus drawn, will not be a ſtreight, but a Conoyd or mixt Line.

Let there be drawn a Right Line at pleaſure, as A B, and another Parallel to it at any diſtance, as C D, at one end of the Line A B, as at A, Erect a Perpendicular at pleaſure, as A E, and draw it down to C; then divide the Line A B, into what Number of Parts you pleaſe, equal or unequal, as at the Points a, b, c, d, e, f, g, *&c.* Then take in your Compaſſes the diſtance A C, and ſet it upon the reſpective Lines that are drawn from C, as from, a, to h, from b to i, from c to k, from d to l, from e to m, from f to n, and from g to o. Laſtly, draw Lines (or rather one continued Line with an even Hand, through the Points h, i, k, l, m, n, and o, and you will find that it ſtill inclines nearer and nearer to the Line A B, but will never concur or meet with it.

# Aſtronomical RECREATIONS.

## CHAP. I.

*A Brief View of the Principles of ASTRONOMY.*

ASTRONOMY was Anciently called ASTROLOGY; But in after times, this Synonomy ceaſed; the former tending only to *Divine* and *Prognoſticate* of future *Events*, from the *Sight* and *Aſpects* of the *Planets* and *Stars*. But the Later (*Viz.* ASTRONOMY) of which I ſhall only Treat; is a *Science* which teacheth the *Laws* and *Rules*, whereby the *Motions* of the *Stars* and *Planets* are *Regulated* and *Determined*. As to the *Original* of this *Science*, it cannot be referred to a better *Patron* then *Admiration*: And ſo ſays *Gaſſendus*; *Originem ipſi fecit Admiratio*: For the *Ancients* admiring the *Splendor*, *Variety*, *Multitude* and *Magnitude* of the *Stars*, together with their *Conſtant* and *Regular Motions*; Transferred their *Admiration* into *Obſervation*, and that (in Proceſs of time) into *Tables*, for the Information of Poſterity.

## CHAP. II.

*Of the* WORLD, *and of ſuch Places as in General it conſiſteth of.*

THere is nothing wherein the wonderful Power and Glory of God is more viſibly expreſſed, than in the admirable Frame of this great Univerſe of Heaven and Earth. And the Reaſons why moſt Men are no more affected with it, are; Firſt, the Commonneſs of the things. Secondly, the ignorance of the Order and Cauſes thereof; whereas they that know any thing hereof, cannot but admire the Works of God herein; as we may ſee by the Prophet *David*, who ſo often ſpeaks hereof in the *Pſalms*. I ſhall therefore as briefly and plainly as I can ſhew you ſome part of theſe Wonders, and then I ſhall

ſhew you how theſe things are found out, and proved to be ſo, that you may not take them for vain Fancies, but in ſome meaſure ſee them to be Truths.

Firſt, you muſt know that in this viſible VVorld there are theſe Eminent parts which deſerve a particular conſideration.

1. The Globe of the *Earth.*
2. The Globe of the *Moon.*
3. The Globe of *Mercury.*
4. The Globe of *Venus.*
5. The Globe of the *Sun.*
6. The Globe of *Mars.*
7. The Globe of *Jupiter.*
8. The Globe of *Saturn.*
9. The Heaven of the fixed Stars.

Some add to theſe,

10. The Criſtalline Heaven.
11. The firſt moving Heaven.

Now concerning the Number and Order of theſe ſeveral Spheres, Globes or Orbs, there are ſeveral Syſtems; Namely, (1.) That of *Pythagoras.* (2.) The Platonick and Porphyrian Syſtems. (3.) The Egyptian Syſtem. (4.) The Copernican. (5.) The Tychonean. (6.) The Hypotheſis of *Ricciolus.* Of theſe ſeveral Syſtems, there are two which are generally received; Namely, the *Ptolomaick,* and the *Copernican*; concerning both which I ſhall briefly inſiſt, for concerning theſe two, there hath been great *Diſputes,* and therefore, I ſhall in this Place give you a brief Account of ſeveral *Objections* made againſt the one, (*Viz.* the *Copernican,*) with their *Anſwers,* and alſo *Arguments* for the Confirmation of the other, (*Viz.* The *Ptolomaick.*) ——And for the better underſtanding of the following Diſcourſes, it will be neceſſary to acquaint you with what a material Sphere or Globe is, and what Circles, Lines and Points are deſcribed thereon, as imagined really to be in the Heavens.

## CHAP. III.

### *Of a Material* Sphere *or* Globe.

THeodoſius, an Ancient and Learned *Mathematician*, who Writ much of the Sphericks, thus defineth a Sphere or Globe. *Sphera eſt ſolidum, una ſuperficie contentum, in cujus medio punctum eſt, à quo omnes rectæ lineæ ductæ ad ſuperficiem ambientem ſunt equales.* That is, a *Sphere* or *Globe* is a ſolid Body, containing one Superficies; in whoſe middle there is a point, from which all right Lines drawn to the Superficies are equal.

Upon

Upon the Superficies of this *Sphere* or *Globe* are deſcribed ſeveral *Circles* and *Points*, (which are only imagined in the Heavens) thereby the better to inform the Fancy; for by them (in the *Cœleſtial Globe*) the ſeveral Conſtellations of the *Fixed Stars* are limited, and their Scituation denominated: And the ſame Circles deſcribed upon the *Terreſtrial Globe*, do confine and bound the Zones and Climates.

Theſe *Imaginary Circles* are in Number *Ten*; of which *Six* are called *Great Circles*, and *Four* or *Leſſer Circles*: Thoſe *Circles* are called *Great Circles*, which being drawn upon the Globe, do divide the Superficies thereof into two equal parts; and thoſe are called *Leſſer Circles*, which divide the Superficies of the Globe unequally.

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## CHAP. IV.

### *Of the* Circles *of the* Sphere.

Every of the forementioned Circles hath a peculiar Name Attributed unto it; and the Names of

*The Six Great Circles, are theſe.*

| | |
|---|---|
| 1. *The Horizon.* | 4. *The Zodiack.* |
| 2. *The Meridian.* | 5. } *The Colures.* |
| 3. *The Equinoctial.* | 6. } |

Of theſe two *Colures*, the one is called the *Equinoctial Colure*, dividing the Sphere into two equal parts in the Points of *Eaſt* and *Weſt*, and the other is called the *Solſticial Colure*, dividing the Sphere into two equal parts in the Points of *North* and *South*: So that theſe two Colures croſſing one another at Right Angles in the *Poles* of the World, do divide the Globe into four equal Quarters.

*The Four Leſſer* Circles *are,*

1. The *Tropick* of *Cancer*; Or the Northern Tropick.
2. The *Tropick* of *Capricorn*; Or the Southern Tropick.
3. The *Circle Artick*; Or the North-polar Circle.
4. The *Circle Antarick*; Or the South-polar Circle.

Beſides theſe Circles, there are upon the Superficies of the Globe, other Points and Lines of ſpecial Note and Uſe: As,

1. The two *Poles* of the World, { North, and South,
2. { The Zenith, } Or Point in { Over our Heads.
3. { The Nadir, } the Heaven. { Under our Feet.
4. The *Poles* of the *Ecliptique*.
5. The *Ecliptique Line*, or *Via Solis*. And
6. There is another imaginary Line ſuppoſed to paſs from *Pole* to *Pole*, through the Body of the *Globe*; and this Line is called, *the Axis*

*of the World*, for that the Motion of the Heavens is wholly upon the Poles of the World.

Having thus given you the Names of the feveral *Circles*, *Lines* and *Points*, which are in the Heavens imagined, I will give you a brief Account of each particular, by which you may eafily conceive how they are drawn upon the *Globe*.

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## CHAP. V.

### *Of the Ufe and Office of thefe* Circles, Points *and* Lines.

#### 1. *Of the* HORIZON.

THE *Horizon* is a great Circle of the Sphere, dividing the vifible part of the Heavens from the not vifible, that is, the lower Hemifphere from the Higher: As fuppofe you were at Sea, or upon a high Hill upon the Land, and looking round about you, you imagine that the *Skie* and *Water*, or the *Skie* and the *Earth* did meet and touch each other. Now this Line of Separation of the *Skie* and *Water*, or *Earth*, is the *vifible Horizon*, and is that which is imagined to be in the Heavens.

Unto this Circle, when either the *Sun*, *Moon*, *Stars*, or any of the *Planets* do come on the Eaft-part of the Heavens, they are then faid to rife; and when any of them come to this Line on the Weft-part of the Heavens, then the *Sun*, or fuch a *Star* or *Planet* is faid to fet: So that the *Rifing* and *Setting* of the *Sun*, *Moon* and *Stars*, are limited and bounded by this Circle.

#### 2. *Of the* MERIDIAN.

The *Meridian* is a great Circle of the Sphere, which paffeth through the *Zenith* and *Nadir* Points, and alfo thro' both the *Poles*, and divideth the *Horizon* into two equal parts in the Points of *North* and *South*, which paffeth through the *Zenith* Point in the Heavens, which is directly over your Head, in what part of the World foever you are, and the *Nadir* (which is the point directly under your Feet, and oppofite to the *Zenith*) and it alfo croffeth or divideth the *Horizon* in the *North* and *South* Point.

Unto this Circle, when the *Sun*, *Moon*, or any other *Star* or *Planet* cometh, it is faid to be upon the *Meridian*, or at the higheft it can be that Day or Night; fo that when the *Sun* rifeth towards the *Eaft* in the Morning, it afcendeth higher and higher, till it cometh to this Circle, and then it is Noon; after which it defcendeth lower and lower, till it fet in the Evening in the Weft-part of the *Horizon*.

3. Of

### 3. *Of the* ÆQUINOCTIAL.

The *Æquinoctial* is a great Circle, dividing the Sphere into two equal parts, and passeth through the *East* and *West* Points of the *Horizon*, and also through the *Meridian* in two Points, which are so far distant from the *Zenith* and *Nadir* Points, as the *Poles* are distant from the *Horizon*: So that the *Axis of the World*, which passeth from *Pole* to *Pole*, cutteth this Circle at Right Angles.

Unto this Circle when the *Sun* cometh (which is twice every year, Namely, about the tenth of *March*, and the twelfth of *September*) it maketh the Days and Nights of equal length through the whole World; for that at that time the *Sun* riseth due *East*, and sets due *West*; which at no other times of the year it doth, but rises and sets Northward of the *East* or *West* Points, from the tenth of *March* to the twelfth of *September*, and Southward of the *East* or *West*, from the twelfth of *September* to the tenth of *March* again.

### 4. *Of the* ZODIACK.

The *Zodiack* is a great Circle, dividing the Sphere or Globe into two equal parts, in the *East* and *West* Points of the *Horizon*, and cutteth both the *Horizon* and *Equinoctial* at oblique Angles; for it cuts the *Horizon* at an Angle equal to the *Suns* greatest *Meridian Altitude*, in any *Latitude*, and the *Æquinoctial* at an Angle equal to the *Suns greatest Declination*. This Circle is called by some, *The Girdle of the World*, it having imbroidered (as it were) upon it, the Figures of the 12 *Cœlestial Signs*. But through the middle thereof, there is a Line, which is called the *Ecliptick Line*, or *Via Solis*, for that the *Sun* in his motion never deviates from this Line (though the other Planets do more or less.) The Poles of this Circle are upon the *Meridian*, so far distant from the Poles of the World, as is the *Suns* greatest Declination.

### 5. *And* 6. *Of the two* COLURES.

The two *Colures* are two great Circles, passing through the *Poles* of the World, and there cutting each other at right Angles: The one of these Colures cutteth the *Ecliptick Line* in the Points ♈ and ♎, and is called the *Equinoctial Colure*: The other cutteth the *Ecliptick* in the Points ♋ and ♑, and is called the *Solsticial Colure*.

When the *Sun* is in that Sign or Point of the *Ecliptick*, which meeteth with the *Equinoctial Colure*, which is in the first scruples of ♈ or ♎, then are the Days and Nights equal: But when the *Sun* cometh to those Points of the *Ecliptick*, which are cut by the *Solsticial Colure*, which are in the beginning of ♋ and ♑; then the *Sun* being in ♋, it maketh the longest day to all the Northern, and the shortest day to all the Southern Inhabitants of the World: And being in *Capricorn*, it maketh the shortest day to the Northern, and the longest to the Southern In-

### 7. *Of the two* TROPICKS.

The *Tropicks* of *Cancer* and *Capricorn*, are two Circles drawn upon the Superficies of the Globe, parallel or equidiſtant from the *Æquinoctial*, on the North and South-ſide thereof at 23 Degrees, 31 Minutes diſtance therefrom; the one is called the *Northern Tropick*, the other the *Southern*. And between theſe two *Tropicks*, is ſeated that part of the World which is called the two Torrid *Zones*.

### 8 *And* 9. *Of the* ARTICK *and* ANT-ARTICK *Circles*.

Theſe are two ſmall *Circles* drawn about the *Poles* of the *World*, and parallel to the *Equinoctial* and *Tropicks*: And the *Circle Artick* is ſo far diſtant from the *North Pole*, as the *Tropick* of *Cancer* is from the *Equinoctial*: And the *Antartick* is at the ſame diſtance from the *South Pole*, *Viz.* 23 Degrees, 30 Minutes, and in theſe two *Circles* and ſeated the two *Poles* of the *Ecliptick*: And between them and either *Pole*, are the two *Frigid Zones*; the two *Temperate Zones*, lying between theſe two *Circles*, and the *Tropicks* of *Cancer* and *Capricorn*.

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## CHAP. VI.
### *Of the* SYSTEM *of the* WORLD.

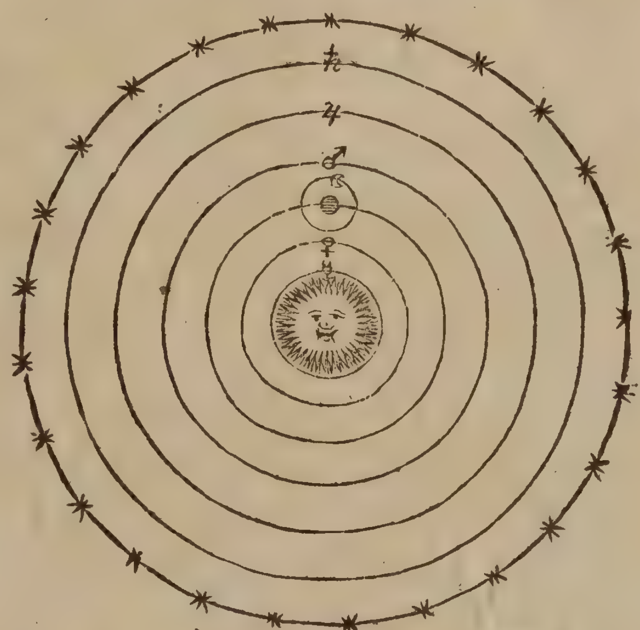
#### 1. Of the *Ptolomaick* Syſtem.


THIS *Syſtem* ſuppoſeth the *Earth* to be in the *Center* of the *Univerſe*; above it the *Elementary Region*; next above that the *Moon*, then *Mercury*; next above him *Venus*, the *Sun* as Chief Moderator

rator of all the rest, in the midst of the *Planets*, environed not only by the three foregoing, called *Inferior*; but likewise by *Mars*, *Jupiter* and *Saturn*, called the *Superior Planets*; above *Saturn* is the *Sphere* of the *fixed Stars*; by some called the *Firmament*.

This was the the first *Pythagorean System*, and was embraced by *Archimides*, the *Chaldeans*, *Aristotle*, *Cicero*, *Livy*, *Ptolomy*, *Alphonsus*, *Purbaccus*; and the greatest part of *Astronomers*, until the time of *Maginus* and *Clarius*.

### 2. Of the *Copernican* System.



THIS *System* giveth to the *Earth*, not only a *Diurnal* Motion about its *Axis*, but also an *Annual* Motion about the *Sun*, as the Center of the *Universe*: This *System*, about two Ages since was resuscitated (but imperfectly) by Cardinal *Casanus*, until *Copernicus* came and gave it a perfect consummation, followed by the greatest Wits of *this* and the foregoing *Ages*.

In this *System* we may perceive the *Sun* placed in the *Center* of the *World*; next above him *Mercury*, finishing his Course about 80 Days: Then *Venus*, making her Revolution in *Nine Months*: Above her the *Earth*, with the *Elementary Sphere*, in the *Annual Orb*, which it runs through in 365 days and a half, by a *Motion* from *West* to *East*; that is, in the same Circle wherein the other *System* places the *Sun*; besides which Annnal Motion, *Copernicus* Assigns to the Earth a *diurnal Revolution*; in which it turns about its own Center in the space of 24 Hours from *West* to *East*: The *Moon* by a Menstrual Revolution being carried about the *Earth* as in an *Epicicle*: *Mars* running about the *Sun*, (as the Center of the Universe,) in two years time; *Jupiter* about him in *Twelve years*; and *Saturn* in *Thirty*: The *Sphere* of the *fixed Stars*, being distant by so vast an Interval from the Sphere of *Saturn*, that the *Annual Orb* in which the *Earth* moves, appears in respect to it, no other then a point.

CHAP.

# CHAP. VII.

## *The* Ptolomean System *strongly Argued for and Maintained, and many of the* Copernican Arguments *Answered by Mr.* Henry Phillippes.

### 1. Of the EARTH.

THis one would think should be perfectly known of us, since it is our natural Habitation wherein God hath placed us; but yet such is our ignorance hereof, that not only among the common sort, but there hath been much to do among the Learned, to prove that this great Body of the Earth and Water is exactly round like a Globe. And it hath been counted a very Fable, that there should be any *Antipodes* or people dwelling in any part of the Earth directly under us, supposing such would be ready to drop down from the Earth into the Heavens. But that the Earth is round, may appear by the round shadow of the Earth upon the Moon, when she is Eclipsed; and likewise by the difference of time, wherein Eclipses are seen in several places. But the most convincing Argument to prove both the roundness and habitableness of all parts of the Earth, whether we account them above, or under, is the daily Experience of our Seamen, who have and do daily Sail about it, specially from the East to the West. And though the Earth cannot be surrounded by the North and South Poles, in regard of the Cold and Ice, yet by the agreement which is found between the distance and the Latitude of places lying North and South, it is evident that the Earth is neither Flat, nor Square, nor Oval (as some have imagined) but perfectly round.

The second thing worthy consideration herein, is the Compass of the Earth. And herein there is much difference between Ancient and Modern Writers, which ariseth partly from the difference of their Measures, unknown to each other. The best Account hereof I suppose is given by Mr. *Norwood*, who for this purpose *Anno* 1635. measured the distance between *York* and *London*, and so exactly taking the Latitudes of those two places, found that one Degree in the Compass of the Earth did contain 367200 of our English Feet; so that the whole Compass of the Earth being 360 Degrees, will be 132192000 Feet, which reduced into Miles, according to the Statute, each Mile containing 5280 Feet, it yields 25036 Miles. By this you may see this Globe of Earth and Water, though it seem so great to some, that it cannot be measured, or incompassed, yet is but a small thing, considered by the Rules of Art; insomuch, that a Ship sailing one hundred Miles every day (which it may well do) it will surround this Globe in 250 days; which is less than three Quarters of a Year.

Thirdly,

Thirdly, It may be enquired, whether the Earth be the Center of the Universe or not; and whether it stands still, or hath any Motion?

For answer hereunto, I say, it hath been the most received, and in my Judgment the best grounded Opinion, That this Globe of Earth is the Center of the Universe, being without any Motion, and that the Sun, Moon and Stars are moved round about it: Yet it was the Opinion of *Pythagoras* and *Aristarchus* (very Ancient Philosophers) that the Sun is the Center of the Universe, and that this Globe of the Earth is turned round about the Sun, together with the Moon, and the rest of the Stars and Planets. This Theory was left off by *Ptolomy*, whom most of our following Astronomers have followed until *Copernicus*, who revived the foresaid Hypothesis, and since that he hath had many followers. And though this may seem to be a very strange Conceit, yet they bring very probable Arguments (in point of Art) to confirm it. In answer to which, I shall propound these Six Considerations.

First, That this Opinion is at the best Fortified, but with probable Arguments; whereas for the standing still of the Earth we have daily a sensible, if not a real Experience. And though our Senses may be deceived herein; yet it will be hard to prove that they are deceived.

Secondly, Though this Theory, in some Respects, doth yield much Harmony in the places and motions of the seven Planets, giving a good Account of their direct and retrograde Motions, without any Epicicles; yet it fails much in the fixed Stars; supposing them to be so far distant from the Center of the Universe, as is beyond all probability. For it is certain by the most accurate Observations of *Tycho Brahe*, and his Successor *Longomontanus*, that there is not the least observable difference in the Latitude of places observed by the fixed Stars, at any one time of the year more than other; no not to the quantity of half a Minute. And therefore if this Theory be allowed, it must be Granted, that there is such a distance between the fixed Stars, and the Center of the World, that not only the Globe of the Earth, but that vast distance of the Sun from the Earth (which is the semidiameter of the Suns Annual motion) must in respect thereof be but a little Point, not causing half a Minutes Parallax, or difference of appearance. Now if such a distance be allowed as is requisite for this purpose, observe how it will exceed all proportion. For whereas *Saturn*, the farthest of the Planets, by the consent of all Astronomers, is distant from the Earth but about 12000 semidiameters of the Earth, the fixed Stars according to this Account must be distant 7904818 semidiameters: So that the place between *Saturn* and the Stars is 7892818 semidiameters, which is 658 times more than *Saturn* is distant from the Center. Thus you see there is no proportion between this vast distance of the Stars above *Saturn*, and the Planets under him. Besides, all this vast distance is but Waste and Useless, there being no Stars, nor any visible Furniture therein, and God and Nature makes nothing in vain.

Again, if according to this foresaid distance you Calculate the quantity of the fixed Stars by their visible Diameters, a Star of the first Magnitude will be greater than the Sun it self 16907143 times, and their true semidiameter, or half the breadth of such a Star, will be more than 8 times the distance which is between the Sun and the Earth.

But theſe things are ſo unlikely, that it makes as much againſt this Hypotheſis, as the other probabilities plead for it.

Thirdly, The Followers of this Opinion hold, that the Earth hath a daily motion, whereby it is turned round about upon its own Axis every day. And for this motion they bring a very plauſible Argument; for by this (ſay they) the incredible ſwiftneſs of the Heavens and Stars is very well ſalved. For if according to *Tycho*, you allow the fixed Stars to be but 14000 ſemidiameters diſtant from the Earth; whereas *Ptolomy* accounts them 20000, yet the Stars near the Equator muſt move every Minute of an Hour 240000 Miles to perform its daily motion round about the Earth. This motion they count too ſwift for any natural body to perform; and therefore think it more likely that the Earth ſhould turn about once every day, and thereby cauſe the riſing and ſetting of the Sun and Stars.

This conjecture is ſo probable, that many who are againſt the Annual motion of the Sun, yet yield to this daily motion: But yet I conceive that the Earth is not ſubject to this motion neither: For if the Earth ſhould according to this Opinion move every day round upon its own Axis, then we which live upon the Surface of the Earth muſt be moved with the Earth above 1000 Miles every Hour. Which motion, though it be very ſlow in reſpect of the foreſaid ſwiftneſs of the Stars, yet conſidered by it ſelf, and compared with the motion of things here below, it is exceeding ſwift, far ſurpaſſing the Flight of the ſwifteſt Bird, or the Bullet from the Cannons mouth. And therefore ſurely if any ſuch motion were, we ſhould be more ſenſible of it, than we are.

But Grant that this motion ſhould be performed by the Earth, and we not ſenſible of it, in regard of conſtant uſe unto it; as men that are uſed to the Sea are not troubled ſo much with the motion of the Ship as others are: Yet judge whether it be not more likely that the Heavens, Sun, Moon and Stars, being all Light and pure Bodies, ſhould perform the foreſaid ſwift motion (though to us almoſt incredible) than that the Earth (a dull and heavy Body) ſhould perform this later motion. As we ſee by experience, that a Horſe being a Creature of a nimble fiery temper, is better able to run 20 or 30 Miles in one Hour, than a Snail which is a dull ſluggiſh Creature to creep one Poles Length, which is ſcarce the ten thouſandth part thereof.

Conſider alſo, that this ſwift motion in the Heavens is no more to be wondred at, than the vaſtneſs of their Circumference; and it is but reaſonable to think, that God who hath made them of ſo great Compaſs, hath likewiſe fitted them for ſo ſwift a motion. And the Truth is, ſwiftneſs of motion depends neither upon the Greatneſs or Smallneſs of the Creature, but upon the appointment of the Creator. Thus we ſee by experience, the little Hare exceeds for ſwiftneſs both the Sheep, a Midling, and the Oxe a Creature of the largeſt ſize; and yet is out-ſtripped by the Dog and Horſe, Creatures likewiſe of the middle and larger ſize. So that it is neither the ſmaller Compaſs of the Earth, nor the larger Compaſs of the Heavens, which can either prove or diſprove the daily motion of either: But herein the wonderful Power of God is the more magnified in making the Heavens, not only by their vaſtneſs to incompaſs the Earth, but alſo by their ſwiftneſs daily to ſurround the ſame.

Fourthly,

Fourthly, Though this Theory in ſome things may be more plainly demonſtrated by Geometry than the Theory of *Ptolomy*, being freed from thoſe Epicicles; yet this may alſo be performed by the Hypotheſis of *Tycho*; and the places and Aſpects of the Planets may be as truly and readily Calculated thereby, as by this. Experience we had hereof in that great Eclipſe of the Sun the 29 of *March* 1652, about which moſt of our Writers following new Tables, according to this Hypotheſis, were greatly miſtaken in the time of the Eclipſe, reckoning it half an hour too ſoon: Whereas I calculating it by the Tables of *Tycho*, and *Longomontanus*, it fell out very exactly. And you ſhall find, that in all the Eclipſes obſerved by *Tycho* and *Longomontanus*, their Tables never failed them ſo much. And for the motions of the Sun and Moon, there are none like them: So that you ſee there is no neceſſity of following this ſtrange Hypotheſis.

Fifthly, This Opinion is againſt the conſtant Tenor and ordinary Phraſe of the Holy Scriptures, which ought to be had in ſpecial Reverence; and from which we ought to be very careful how we vary in any thing, pretending the Scripture ſpeaks herein, according to the ſenſe and apprehenſion of common people, eſpecially when the thing pleaded for is ſo unlikely and unneceſſary.

Laſtly, This Opinion is of dangerous conſequence, the followers thereof being ſubject to fall into many vain curioſities, and Fruitleſs Errors: As that the Moon, and the reſt of the Planets and Stars, may be each of them habitable places, as well as the Earth; and ſome have Written largely to prove, that there is a World in the Moon, and that our Earth gives light unto them, as the Moon doth unto us; and ſo Account the Earth to be as one and the ſame kind with the Stars and Planets; whereas it is plain in *Gen.* 1. that God made the Earth on the third day of the Creation, and furniſhed it with all ſorts of Herbs and Trees; but the Sun, Moon, and Stars were not made until the fourth day: Which is enough to prove them Creatures of a different kind and nature; and we cannot find the leaſt hint that God made the Moon, *&c.* for an habitable place, or the Earth to give Light to the Heavens; but *Ver.* 14, 15. it is plainly expreſſed, that *God ſaid, Let there be Light in the Firmament of Heaven, to ſeparate the Day from the Night. And let them be for Lights in the Firmament of Heaven, to give Light upon the Earth; and it was ſo.* There is not a ſyllable of the Earths mutual and reciprocal Light.

To conclude this particular, moſt of you I ſuppoſe are ready enough to think, that theſe Men err very much in making the Heavenly Bodies to be Earthly Habitations; yet give me leave to tell you, that there is a more common and dangerous Errour, which we had all need to take heed of; and that is, that we do not account this Earthly Dunghil to be our Heavenly Habitation, by laying out all our Care and Pains upon it: But whilſt we live upon the Earth, let our Converſations be in Heaven, from whence we look for a Saviour, the Lord Jeſus Chriſt. And now leaving the *Earth*, it is time to aſcend to the other Orbs, *Viz.* That of the *Moon*, *Mercury*, *Venus*, the *Sun*, *Mars*, *Jupiter*, *Saturn*, the *fixed Stars*, the *Chriſtaline*, and firſt moving Heavens.

## 2. *Of the* Moon.

It is time for me now to leave the Earth at reſt in the Center, and to ſpeak of the Heavenly Bodies and their Motions. And the Moon in the firſt place preſents her ſelf, being by the conſent of all Aſtronomers placed next the Earth.

Firſt, for the Form or faſhion of the Moon, it is round every way like a Globe. And this may be proved by the ſucceſſive and proportional Light which it receives from the Sun; for if it were round and flat like a Trencher; then the Light of the Sun coming to the flat ſide would preſently ſpread all over it, as it doth upon the flat ſide of an Houſe or upright Wall.

Secondly, As for the matter of the Moon, or what ſubſtance it is made of. Thoſe that hold the motion of the Earth, they think the Moon to be very little different from the Earth, having Sea and Land, Mountains and Valleys: And this they gather from the ſpots which are ſeen in the Moon, accounting thoſe darker places to be Sea, and the brighter places to be Land. But I conceive the Moon to be of ſome like ſubſtance with the Clouds: For if you look upon the Moon in the day time, you ſhall ſee many times in a fair day, when the Clouds are High and White, that the Moon and they are all of one Colour. Again look upon the Clouds in ſuch an Evening about Sun-ſetting, and you ſhall perceive the Clouds to reflect the Light of the Sun, and to ſhine as the Moon doth: And this Light thus reflected from the Clouds and the Vapours of theſe lower Regions, is the Cauſe of the Twilight, which continueth till the Sun is 18 Deg. under the *Horizon*, and then the ſhadow of the Earth falling upon the Clouds, doth take away their ſhining, juſt as the Moon loſeth her Light in her Eclipſe, which proceeds from the ſame Cauſe. Add to this the many Reſemblances of many Suns and Moons, which are divers times ſeen in the Air, which are nothing elſe but Clouds fitly formed and placed to Reflect the Light of the Sun unto us. All this may ſhew, that the Moons ſubſtance doth in ſome ſort reſemble that of the Clouds. And as for the duration of the Moon, longer than the Clouds, this it hath by Gods appointment, who alſo cauſed that Cloud to Guide the *Iſraelites* 40 years in the Wilderneſs, which was a Pillar of Cloud by Day, and a Pillar of Fire by Night.

Thirdly, It is a common queſtion, whether the Moon have any Light of her own? or whether ſhe receive all her Light from the Sun?

For anſwer hereunto, conſider that there are ſeveral ſorts of Lights; firſt there are ſome things that have not only Light in themſelves but give Light to other things, as the Fire and the Sun. Secondly, there are ſome things that have no great Light in themſelves, yet they ſhine in the Dark; as Glow-worms, Rotten-wood, and Fiſh-Skins. Thirdly, there are ſome things which may be ſaid to have Light, but this Light appears beſt in a greater Light; as white things, poliſhed Metals, Glaſſes and the Clouds. And ſuch a Light I conceive the Moon hath of her own, whereby ſhe is fitted to Reflect the Light of the Sun to our Sight. Yet I do not think, as ſome have ſuppoſed, that the Moon is ſo perfect a mirror as that the ſpots which we ſee in the Moon

Moon are nothing elſe but the Image of our Earth and Sea which we ſee therein; as when we look upon a Glaſs we behold our own Image therein: Much leſs do I believe what ſome have ſaid, that things done, or a Writing ſet before the ſhining Moon, may be ſeen and read in the Moon at an other place of the World, very far diſtant from it; as by the Reflection of Glaſſes it may be performed for a ſmall diſtance.

Fourthly, If you demand what may be the Reaſon of thoſe ſpots which are ſeen in the Moon? I anſwer, they proceed from the roughneſs and inequality of the Moons Body. For though the Moon hath not Hills and Dales, Mountains and Valleys; yet as you ſee the Clouds are many of them ragged things, and not ſmooth and plain, ſo it may very well be in the Moon, though in regard of her diſtance they are not ſo diſcernable. And this ſuppoſition will very well agree with all the Obſervations of theſe ſpots, both in the New and Full Moon. For firſt, in the New Moon, by Reaſon of this inequality of the Moons body, ſome little ſpots of Light will appear before the main body of Light, on the tops of theſe rough places, and then again towards the Full Moon, this inequality will cauſe much difference in the Light of the Moon: Juſt as you ſee when the Sun ſhines full upon a Glaſs Window, though the Window be in a manner flat, yet if the panes of Glaſs lie never ſo little ſlanting, it will cauſe a difference in the Reflection, and one place will ſeem darker than another.

Fifthly, As for the quantity of the Moons body, and her diſtance from the Earth: How theſe things come to be known, I ſhall ſhew hereafter: In the mean time, it ſhall ſuffice to tell you, that according to *Tycho*, the Moon is diſtant from the Earth 56 ſemidiameters of the Earth, which reduced into Engliſh Miles, is 223048 Miles. And though the Moon appears ſo little to us in regard of this diſtance, yet the true Diameter or Breadth of the Moon is 2060 Miles, and the Compaſs of it 6474 Miles; ſo that the Breadth and Compaſs of the Moon is a little more than the one quarter of the Breadth and Compaſs of the Earth; and if you regard their ſolid Proportions, the Earth is 50 times bigger than the Moon.

Laſtly, The Moon hath a four-fold motion: The firſt is its daily motion, wherewith it encompaſſeth the Earth in 24 Hours 48 Minutes. The ſecond is her motion in the Zodiack, wherein ſhe is the ſwifteſt of all the Planets, running through all the Twelve Signs in 27 Days, 7 Hours, 43 Minutes. Thirdly, ſhe hath her motions from the Sun, whereby is cauſed the diverſity of her appearance; this motion is finiſhed in 29 Days, 12 Hours, 44 Minutes. Fourthly, ſhe hath a motion of Latitude from the Ecliptick Line, or way of the Sun, which is the Reaſon that there are not Eclipſes every New Moon and Full Moon; and this motion is finiſhed in 18 Years, 7 Months, and 12 Days. Many good Uſes might be made of theſe motions; but of theſe I have, and ſhall ſpeak more in its time.

3. Of

## 3. *Of* Mercury *and* Venus.

I put theſe two Planets both together; for though they have ſome difference in their motions, yet in ſome reſpect they are both alike: Theſe as two diligent Pages, continually wait upon the Sun their Lord, being never far diſtant from him.

As for their order in the Heavens, *Ptolomy* placeth *Mercury* next above the Moon, and *Venus* next above him, both under the Sun. But herein *Tycho* in ſome ſort agrees with *Copernicus*, and the later Aſtronomers all conſent therein, making the Sun the Center of the Planets, and ſo they place *Mercury* next the Sun, and *Venus* a little further off the Sun; ſuppoſing them to turn round about the Sun, as it were in two little Circles; ſo that either of theſe Planets, are ſometimes above, and ſometimes under the Sun: And ſometimes *Venus* may be nearer to the Earth than *Mercury*.

Hereby alſo you may perceive the cauſe why theſe two Planets are never very far diſtant from the Sun, for they can go no farther than their Circles will give them ſcope: which for *Mercury* is about 29 degrees; and for *Venus* about 48 degrees.

*Mercury*, by reaſon of his continual nearneſs to the Sun, and the ſmallneſs of his body, is ſeldom ſeen. But *Venus* by her Luſtre is known unto all men; ſhe ſometimes runs before the Sun, and then ſhe is called the Morning Star, ſometimes ſhe follows the Sun, and then ſhe is called the Evening Star. And ſo great is her brightneſs (by reaſon of her nearneſs to the Earth) that ſhe is not only ſeen in the Night, but many times in the Day, which many will gaze at; but the Learned and Diligent *Tycho* made a very good uſe of it: For by obſerving the diſtance between the Sun and *Venus* in the Day time, and then the Night following obſerving the diſtance from *Venus*, to ſome of the fixed Stars, and from them to others; he thereby found out their places more exactly than by any way elſe he could attain to. But if ſuch an Eclipſe had happened in his time as that of the 29th of *March* 1652, or that *Auguſt* 9. 1654. both which happened about High-noon, wherein ſome of the fixed Stars were ſeen, he might have performed this concluſion with more eaſe and certainty. And I hope ſome lover of Aſtronomy or other, hath made ſuch uſe of this occaſion, which would be of great concernment, either for the rectifying or confirming of former Obſervations, in this ſo neceſſary a part of Aſtronomy. And I hope if all have neglected it this time, that ſome will be diligent in it, at the next great Eclipſe of the Sun.

The diſtance of theſe two Planets from the Earth, is ſomewhat different, but according to their middle diſtance they are accounted to be removed from the Earth, as the Sun is, of which you ſhall have more in the next Section. The breadth and compaſs of their bodies is thus:

| | | | |
|---|---|---|---|
| Breadth of | Venus | 4397 | Miles. |
| | Mercury | 2931 | |

Compaſs

Compass of { Venus 13800 / Mercury 9354 } Miles.

## 4. *Of the Sun.*

The Sun is the principal and chiefest of all the Planets and Stars, being the Fountain of all the Light we receive; and therefore is most fitly placed in the midst of the Heavens. As for the matter of it, it cannot be no other than pure Fire, as is manifest by the effects thereof, Light and Heat: For though Heat may be without Lustre in some things, and Lustre without Heat in many other things, yet Heat and Lustre both cannot be without Fire: But this Fire I speak of, you must not imagine to be any gross Fire, but pure Elementary Fire, which needs not the continual supply of Fuel, but of it self is lasting and durable. For though the Psalmist saith, *Psal.* 102. 26. that *the Heavens shall wax old as a Garment*, this is rather by the Sin of Man than by their own Nature.

This Sun, as it is the most glorious, so it is the most useful Creature of all others, being not only the Fountain of Light, but the Fountain of Life unto all Creatures; this made the Heathen Worship him for a God; and the Jews, though better Instructed, and expresly forbidden, could scarce refrain from this Idolatry, but Worshipped the Sun and Moon. Let us take heed of this, but let us praise God for them, and with them, who made both us and them, as we are exhorted, *Psal.* 148. *Praise him Sun and Moon, praise him all ye Stars of Light; for he commanded, and they were created.*

As for the motion of the Sun; First, It hath a daily motion round about the Earth, by which it makes the Day and Night. Secondly, It hath a Yearly motion round about the Heavens, whereby it causeth Summer and Winter, Spring time and Harvest: This course it finisheth in 365 Days 5 Hours, 49 Minutes, which odd 5 Hours 49 Minutes, in 4 Years makes up almost one whole Day, and is therefore added every fourth Year or Leap-year; for otherwise, in a little time the Month of *June* would fall in the Winter, and *December* in the Summer, as it did in the Egyptian year. But this was thus rectified by *Julius Cæsar*, which account, though it was far more exact than any of the former, yet by reason that those odd hours and minutes did lack 44 minutes of one day in those 4 years, it hath caused some alteration in the year since his time. For whereas the Sun in his time entred into *Aries* on the 25th of *March*, it now enters into *Aries* about the 10th of *March*; and hereupon Pope *Gregory Anno* 1582, caused ten days to be cut off from the old Account, and this is the reason the Account beyond Sea is ten days before ours, which makes their *Easter*, and all their Movable Feasts, fall most times before ours.

The distance of the Sun from the Earth, according to *Tycho*, is 1150 Semidiameters of the Earth, which reduced into Miles, is 4580450 Miles. The diameter or breadth of the Suns body is 42600 Miles; and the compass thereof is 133886 Miles; so that the compass of the Sun is above 5 times the compass of the Earth: But if you have regard

to

to the ſolid contents thereof, then the Sun by this Account is 153 times bigger than the Earth.

As for the daily compaſs which the Sun runs in the Heavens, it is 28789124 miles; ſo that every hour it runs 1199547 miles, which is every minute near upon 20000 miles. And yet to perform ſo ſwift and continual a motion, the Sun needs neither the Poetical Fiction of Horſes to draw it, nor the more probable Opinion of the Earths daily motion to eaſe it of its labour; but by the appointment of God, *cometh forth as a Bridegroom out of his chamber, and rejoyceth as a mighty man to run his race: his going forth is from the ends of the Heavens, and his compaſs to the ends of the ſame*, Pſal. 19.5,6.

### 5. *Of the Three Superiour Planets*, Saturn, Jupiter *and* Mars.

Theſe three Planets are accounted by all Aſtronomers to be farther from the Earth than the Sun. As for the motions of theſe Planets, tho their daily motions are ſwifter than the other Planets, being farther diſtant from the Earth, yet their periodical motions are more ſlow; and according to their diſtance from the Earth, ſo is their ſlowneſs. For *Mars*, the neareſt of theſe three, finiſheth his courſe in one year 322 days. *Jupiter* the next, in 11 years 318 days. *Saturn*, the fartheſt, in 29 years 174 days; in theſe times they run thorow the 12 Signs in their Ecliptick.

Beſides theſe motions, there is alſo a retrograde motion, which not only thoſe three, but *Venus* and *Mercury* are ſubject to. Indeed, the Sun is exempted from it (as it were by extraordinary priviledge) and the Moon avoids it by her ſwift motion; but *Mercury* and *Venus*, tho in their mean motion equal to the Sun, yet are often driven backward.

*Mercury* is the moſt often ſubject hereunto of all the Planets, being very inconſtant in his motion; running over this motion every 116 days, being direct 92 days, and then retrograde 24 days. *Saturn* is more conſtant and ſerious in his walk, renewing this motion once in 378 days, being direct 238 days, and retrograde 140 days. And *Jupiter*, his next Neighbor, as it it were to keep him company, walks this round in 399 days, going forward 279 days, and then backward 120 days. But Warlike *Mars*, as ſcorning to turn his back, marches on furiouſly for 700 days together, yet then he is forced to countermarch as faſt for 80 days. Laſtly, Dame *Venus*, proud of her Beauty, which ſhe is loth to have too long hidden, or fears will be too much burned by the Sun, runs as faſt as ſhe can before him for 542 days; but when ſhe ſees the Sun will over-take her, ſhe turns about and runs the contrary way for 42 days, that ſo the Sun may the ſooner overſhoot her, and ſhe may again ſhew to the Earth her glorious Luſtre. Theſe motions you may evidently ſee in theſe Planets, if you obſerve their ſituation Nightly in reſpect of the fixed Stars; but the farther ground and demonſtration hereof, I have not time to ſpeak of.

Laſtly, For the diſtance of theſe three Planets from the Earth, *Mars* is diſtant 1745 Semidiameters, *Jupiter* 3990, *Saturn* 10550, which being granted, their diſtance, breadth, and compaſs in Miles, is thus:

*Diſtance.*

| | Distance. | Breadth. | Compass. |
|---|---|---|---|
| *Mars* | 6950535 | 3336 | 10484 |
| *Jupiter* | 15892170 | 12800 | 40228 |
| *Saturn* | 42020650 | 21920 | 68891 |

## 6. *Of the Fixed Stars.*

I call these *Stars* fixed, not because they are void of all motion, but because they keep their places very exactly one in respect of another. Insomuch, that those Stars which were to be observed in a right line by *Hipparchus* 1700 years ago, were found so by *Ptolomy* in his time 1300 years ago, and continue in the same posture still, as you may see by many Examples in *Tycho, lib.* 1. *p.* 134. Therefore it is very probable that they all are fixed in one Sphere, and are all equally distant from the Earth, since they are so uniform in their motions.

The motions of these Stars are two: The one daily from East to West, the other yearly according to the order of the Signs. In their daily motion they are exceeding swift; for the compass of their *Heaven* is above 350000000 of Miles; so that those Stars which are towards the Equator, must move 240000 Miles every minute of an hour. But in their other motion they are exceeding slow, not moving one whole minute in a year, but only one degree in 70 years; so that they will be 25000 years in making their progress through the 12 *Signs*. This motion by the Ancient Astronomers was thought to be finished in 36000 years, and is called by some the *Platonick year*: At which time, according to their Opinion, all the Stars having finished their Revolutions, shall return unto their first places; and that all other things shall return with them again to the same order wherein they were. But this Opinion is very vain, for neither will the motions of the Planets and Stars, calculated together, agree to such a Revolution. And the Apostle *Peter* affirms, *That both the heavens and the earth which now are, shall be destroyed with fire at the last day*, 2 Pet. 3. 7. which will certainly be long before this Period.

Concerning the number of the Stars, though it be great, yet it is not infinite. Astronomers take notice only of about 1000, which are the most conspicuous, and though sometimes in a clear Winter Night many more little ones may be perceived, yet they cannot certainly be observed; and those aforesaid seem many more than they are.

The Ancient Astronomers, the better to distinguish and describe these Stars, have drawn them upon their Globes and Maps in 48 Images; so that every Star comes to have a Name from that part of the Image they are placed in: As the *Bulls Eye*, the *Lions Heart*, and such like. Some Modern Astronomers have added 12 Constellations more towards the South Pole, which were not known to the Ancients.

Another way whereby these Stars are diſtinguiſhed, is by their ſe-veral bigneſſes, amd to this purpoſe they rank them into 6 Magni-tudes. This diſtinction is far more apparent than the other, the Con-ſtellations being only Poetical and Imaginary, this difference real and viſible. But though the biggeſt of theſe Stars ſeem little in regard of their great diſtance from us, yet are they of wonderful greatneſs. For if you reckon only their diſtance according to *Tycho*, to be 14000 ſemidiameters of the Earth (whereas *Ptolomy* allows 20000) this re-duced into Miles, yields 55762000. Which being ſuppoſed, their Breadth and Compaſs, according to their viſible Diameters, will be as followeth.

| Magnitude | Breadth | Compaſs | Number |
|---|---|---|---|
| 1 | 32342 | 101643 | 15 |
| 2 | 24256 | 76232 | 45 |
| 3 | 16843 | 52935 | 208 |
| 4 | 12128 | 38116 | 474 |
| 5 | 08085 | 25410 | 217 |
| 6 | 05090 | 16941 | 49 |

Hereby you ſee, that the ſmalleſt Stars are almoſt as big as the Earth, the Compaſs of the Earth being 25036 Miles, as we ſhewed before. The next ſort are full as big, or bigger, and all the reſt in Order, far exceed the Earth. So that a Star of the firſt Order is four times the Breadth and Compaſs of the Earth; which Cubically conſidered, renders the Stars 65 times greater than the Earth. Thus the leaſt things in Heaven are great, though they ſeem ſmall, and the greateſt things on Earth are ſmall, though they ſeem great. Let this teach us to eſteem of things, not as they ſeem, but as they are.

### 7. *Of the Chriſtalline Heaven.*

This is fitly called the Watery Heaven, whoſe place is above the Stars: For though no ſuch thing is apparent to our Eyes, yet the Scriptures make frequent mention of it. This was the Work of the ſecond Day in the Creation, *Gen.* 1.6,7. *Again, God ſaid, Let there be a Firmament in the midſt of the Waters, and let it divide the Wa-ters from the Waters. Then God made the Firmament, and ſeparated the Waters which were under the Firmament, from the Waters which were above the Firmament.* This, though ſome interpret of the Waters in the Clouds, yet it cannot be ſo meant, for the Clouds are far below the Firmament, thoſe Waters are above it; Beſides, the Clouds are but Vapors ariſing daily out of the Earth. And though this may ſeem ſtrange to Senſe or Reaſon, yet it is the beſt way in this Point to Re-ſolve with *Du Bartas*,

*I.ll rather give a thouſand times the Lye*
*To mine own Reaſon, than but once deny*
*The Sacred Voice of that Non-Erring Spirit,*
*Which doth ſo plainly and ſo oft aver it,*

That

*That God above the Higheſt Firmament,*
*I wot not, I, what kind of Waters Pent.*
Pſal. 104. 3. Pſal. 148. 4.

And the better to perſwade you to this, conſider what he ſaith afterwards;

*I ſee not why Mans Reaſon ſhould withſtand,*
*Or not believe, that God, whoſe Powerful Hand*
*Bay'd up the* Red Sea *with a double Wall,*
*That* Iſrael's *Hoſt might 'ſcape* Ægyptian *Thrall:*
*Could prop as ſure theſe Waters thus on High,*
*Above the Heavens Starry Canopy.*

And here, by the way, let thoſe who plead for the motion of the Earth, and the ſtanding ſtill of the Sun, contrary to the conſtant Phraſe of the Holy Scriptures, ſee what Force is in their excuſe, as if the Scriptures in theſe things, ſpake only according to our Common Senſes, and the Vulgar Opinion; and not the real Truth, according to Nature and Art, to inform our Judgments. I am ſure in this Point the Scripture ſpeaks a Truth, which paſſeth both the Senſe and Art of Man to apprehend. And not only in this one particular, but many other things, there are ſet down in the Creation, which are above, though not contrary to the Rules of Philoſophy: As that there ſhould be day, three days before the Sun. That the Trees and Plants ſhould ſpring and grow without the Sun, which is the natural Cauſe of their Production. That the Bird ſhould be before the Egg, which is prepoſterous in natural Generation: Yet theſe things we ought to believe, much more ſuch things as are more conformable to our ſenſe and common Experience.

What may be the uſe of theſe Waters, is very difficult to determine, the Scriptures herein being ſilent. Some think they were partly uſed for the drowning of the Old World: For it cannot be made good that ſo much Water could probably deſcend from the Clouds, the Waters being above the higheſt Mountain, and many of theſe Mountains being higher than the Clouds themſelves. Neither is this Phraſe uſed to ſet forth the Rain that comes from the Clouds.

Others think that thoſe Waters are placed here, for the cooling of the Firmament, which elſe would be ſet on Fire by its ſwift and continual motion; and that the daily Conſumption of theſe Waters, will be a ſecondary Cauſe of the Burning of the Heavens and the Earth at the laſt day. But theſe things are uncertain. The beſt uſe of them is ſet forth by the Prophet, Pſal. 148. 4. *Praiſe the Lord ye Heavens of Heavens, and ye Waters which are above the Heavens.*

## 8. *Of the firſt moving Heaven.*

Above all theſe (by the Opinion of many) there is a great vaſt Sphere incompaſſing all the reſt, which is called the *Firſt-moving Heaven*; this is ſuppoſed to move round every 24 Hours, and therewith to carry round about all the Stars and Planets every day. But as this is above our ſenſes to perceive it, ſo the Reaſons they bring to prove

it, are not of ſufficient Force. And I rather think that God hath indowed theſe Cœleſtial Bodies with an inward Power to perform their ſeveral motions. For though they are not living Creatures, as ſome have imagined ; yet they may have a Propenſity to move to a certain Point, or in a Circular motion ; as we ſee the Load-ſtone doth, being fitly placed.

For ſuppoſe thoſe Heavens, or Heavenly Bodies had need of any outward Cauſe of their motions : Yet how can this *Primum Mobile* yield them any help therein. For though it might move the higheſt Firmament wherein the Stars are, and which keep a Uniform motion among themſelves ; yet how can it move the Planets which are farther from it, and have ſo many ſeveral motions ? They anſwer to this, that the diverſity of their motion proceeds from their diſtance from this Firſt Mover, which thereby hath the leſs Force over them, to hinder them in their proper Motions from the Weſt to the Eaſt. But to this it may be replied, that if they have a Power of themſelves to perform the one motion, why can they not perform the other daily motion likewiſe by their own Power.

The Reſolution of theſe motions might much better depend upon the daily motion of the Earth upon its own Axis ; and did not the Scriptures ſo oppoſe this motion, I ſhould willingly aſſent thereunto. But I ſhall find this one Argument more againſt this Opinion of the *Copernicans*. For they ſuppoſing the Earth to be a Planet, how then can they think that the Earth ſhould have any other motion than the reſt of the Planets ? Now that the other Planets have no ſuch diurnal motions upon their own Axis, is apparent by the Moon ; which if ſhe had any ſuch motion, the ſpots in the Moon would not appear always in the ſame place of the Moon as they do, both on the Eaſt and Weſt of the Meridian : For if the Moon were turned round, theſe ſpots would be ſometimes on the one ſide, and by and by on the other. But if you obſerve theſe ſpots, you ſhall find the Picture of the Man in the Moon, continually on the Weſtern ſide of the Moon ; and though ſome variation it may have in reſpect of the vertical Point, yet in reſpect of the Pole of the *Ecliptick*, it keeps the ſame place very exactly, juſt as the Horns of the Moon do in the prime and later part of the Moon.

*Thus I have aſcended to the Higheſt Parts of the Viſible Heavens, and have (I hope) in ſome Meaſure performed my Promiſe.*

CHAP.

## CHAP. VIII.

*Containing some of the strongest Arguments (by way of Objection) the Maintainers of the* Ptolomean System *bring against the* Copernican System: *With the* Answers *the* Capernicans *give unto them. Extracted out of the Writings of* Pythagoras, Galileus *and other later* Astronomers.

### OBJECTION I.

THeir First Objection is against the Motion of the Earth: *For* (say they) *We see the Sun, Moon and Stars Rise in the East, and make a Progress by the South, and set in the West: And therefore our Visual Sense Demonstrates, that they move, and not We.*

### ANSWER.

In Answer to this, it may be urged; That the Sense of seeing is deceitful, and makes that seem to move which stands still, and that stand still which moves; as is often seen upon the Water. For, Rowing in a Boat, the Boat shall seem to lie still in the Water, and the Banks of the shore shall seem to slide away from us: And many times the Moon and Stars shall seem to go along with us, which way soever we go.

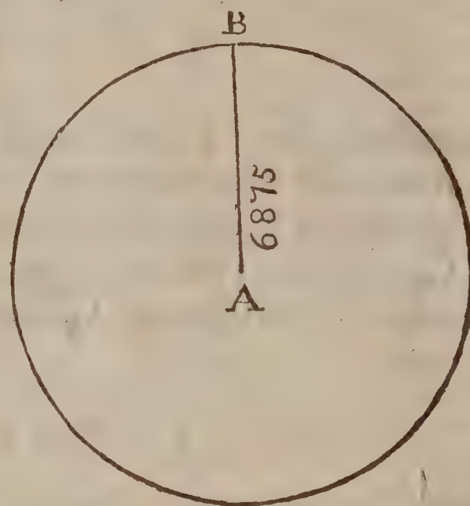
### OBJECTION II.

*If we stand upon a Hill (or on the Top of a main Mast of a Ship at Sea) then Looking round about us, the Heavens appear on each Quarter exactly Equidistant from us: Therefore the Earth is in the Center of all the Heavens: For, were it in any other Place, we should perceive one part of the Heavens nearer to us than another; and the Stars would shew Greater on that part of the Heaven, which shews near to us, and less to that part of Heaven which shews farthest from us.*

### ANSWER.

The Distance of the *Starry Heaven* from the *Sun* (which is the Center of the *Starry Heaven*) is so vast, and the distance of the *Earths Orb* so small, that it seems in the very *Center* it self, and therefore makes

makes in the *Sight* no Alteration; as by this following *Scheme* and *Example*, may be eaſily conceived: Wherein imagine this Circle, repreſenting the *Starry Heaven*, to be 20 Inches Diameter: A is the Center of the Circle, which is, in all parts, equidiſtant from the *Circumference*. This Line AB will then be 10 Inches. Now ſuppoſe the Line AB were divided into 6875 equal parts (for the *ſemidiameter* of the *Starry Heaven*, contains the *ſemidiametir* of the *Earths Orb* 6875 times) and that the *Center* were removed from its true place at A, one of thoſe equal Parts: Then may you, firſt, conſider the apparent Length of one of thoſe Parts; and ſecondly, what difference, in appearance from the *Center*, it would have: If then the whole Length A B 10 Inches, be divided into 6875 equal Parts, then ſhall every Inch be divided into 637½ Parts, which is ſo ſmall, that it exceeds not half the Breadth of a Hair of ones Head: And what difference, at the *Circumference*, half a Hair Breadth will make from the true *Center* of a *Circle* of 20 Inches Diameter, is to be conſidered. It is true, it is a difference from the true *Center*, but ſo ſmall, that no Man with the Point of a Needle can make a perceptible *Mark* of that Size. Now, though the diſtance of the *Earths Orb*, from the *Center* of the *Starry Heaven*, be ſo ſmall that it is ſcarce diſcernable, by Reaſon of the vaſt diſtance of the *Starry Heaven*, yet the diſtance of the *Earths Orb* from the *Orbs* of *Mars* and *Venus* is not ſo great, but that a ſenſible difference appears at ſeveral times in the ſight of theſe *Planets*: For *Mars* in his *Perigeum* (or when he is *neareſt* to the *Earth*) appears 60 times bigger than in his *Apogeum* (or when he is at his *greateſt* diſtance from the *Earth*) and *Venus* in her *Perigeum*, appears 40 times bigger than in her *Apogeum*: As (with good *Teleſcopes*) hath been Obſerved by *Galileus* and others ſince.




## OBJECTION III.

*It is againſt Reaſon (ſay they) to think the Earth ſhould turn round; for then, we ſhould, every Converſion have our Feet turned upwards, and our Heads hanging downwards in the Air: Our Houſes would tumble over; and every looſe thing, as Stones, Animals,* &c. *Fall from the Earth, as having nothing to reſt their Weight upon.*

## ANSWER.

It is unreaſonable to think *Nature* ſhould create any thing to its own Deſtruction; which we muſt allow, in caſe the Place Aſſigned it by *Nature* be not quite enough to retain it; for nothing can ſubſiſt without

without a proper *Place*: But we see it customary with *Nature* to Act beyond *Vulgar Reason*: For, whither the *Earth* turn *Round*, or stand fix'd in the *Center*, it matters not in this *Argument*: For, we all allow the *Earth* to be *Round*, and few Men now are so unskilful in its *Shape* or *Figure*, as with *Lactantius*, to deny an *Antipodes* to every Place on the *Earth* and *Sea*. Which *Antipodes*, according to his *Argument*, is as much subject to these *Casualties*, as the whole *Earth* in its *Conversion*: Nay, the whole *Earth*, by admitting *Antipodes*, runs equal hazard of dropping all loose things into the *Air*, as admitting of the *Eraths* Conversion does.

## Objectiog IV.

*If according to the* Copernican *Doctrine, the Earth move round from West to East in* 24 *Hours, then (admitting the Circumference thereof to be* 21600 *Miles) it must in one Hour move* 900 *Miles, and in a Minute* 15 *Miles, and in the fifth Part of a Minute* 3 *Miles. So that if a Stone be let fall from an High Steeple, and it be the fifth part of a Minute in falling, by that time the Stone comes to the Ground, the Earth should have passed from West to East three Miles, and the Stone must (by consequence) fall three Miles to the Westward of the Bottom of the Steeple. And to this Objection may be added another ;* Viz. *That* Pigeons *may by strength of their Wings fly three Miles to the Westward from their Dove-House in one quarter of an Hour: But in this time should the Dove-House, by the Earths motion be receded Eastward* 225 *Miles. which with the acquired motion of* 3 *Miles, makes* 228 *Miles, and then they should alight* 228 *Miles off from their Dove-House: Both these Arguments, and several other of the same Nature, experience contradicts; and therefore the Earth stands still.*

## Answer.

By the *Earth*, is not meant only this bare *Ball* of *Earth* and *Water* whereon we dwell; but the whole *Body* as it is Cloathed with the *Elements* of *Air* and *Fire*: For these *Elements* are frequently convertible into each other: And as *Philosophers* teach us, are never so purely *one*, as not to have a mixture of *all*: Therefore, whatsoever is within this *Sphere* of *Elements*, we say is in the *Earth*, though part of these *Elements*, for their Purity, be Elevated above the Surface of that solid Body of *Earth* wherein we go: And therefore when we say the *Earth moves*, we do not mean only that part of the *Elementary Sphere* which we call *Earth*; but by the *Earth* we mean the whole *Body* of *Elements*, which is according to this *Doctrine* agitated by one single Activity; and what ever moves in any part of this *Sphere*, moves in *all*: *As for Example*, The *Stone* and the *Doves* being *Elementary Bodies*, are inclosed within the *Sphere* of the *Earths* Activity; *Viz.* Within the *Air* of the Highest, and therefore have the *Motion* imprest upon them that the *Earth* hath: For which way soever the *Stone falls*,

or is *thrown*; or which way soever the *Pigeon* Flies, they move along *Eastwards* with the *Earth*, though they fly *Westwards*. Thus Experience shews, That if a *Ship* Sails with a *swift* motion *Westwards*, it may in one *Second* of *Time* run about 9 Foot; and if one let fall a *Stone* from on high into the *Hold*, that *Stone* shall not fall 9 Foot *Eastwards* from the Perpendicular Point, but just upon the same Point in the Bottom of the *Hold* it would have fallen, if the *Ship* had lain still, *Viz.* on the Point Perpendicular to the *Point* above it, from whence it was let fall; whereas, if the *Stone* had not received the Imprest motion of the *Ship*, it must have fallen 9 Foot to the *Eastward* of that Point.

## Objection. V.

*The* Earth *is a* Heavy Body, *and therefore unfit for* Motion, *especially through the pure Heavens; for such is the sublimity of them, that the* Weight *of the* Earth *would press through them, and so it should lose its Place.*

## Answer.

If the *Earth* be a *Heavy Body*, yet it is not unfit for *Motion*, if the moving Power be strong enough to set it going: But *Heavy Bodies* are more unfit to lie still in the sublime Heavens, than to move in them: For thus we shall see, a *Stone* thrown into the *Air*, whilst it hath *Motion* it will abide there, but when the *motion* dies, the *Stone* falls.

These are such *Objections* as are Vulgarly made against this *Opinion*. There are others, which by some, may seem of more weighty Concern, as being against *Sense*, *Reason*, *Experiment* and *Demonstration*. Now such as desire farther satisfaction in these particulars, may Read *Copernicus* himself, *Kepler*, *Bullialdus*, *Lansbergius*, *Gallilæus*, *Helvetius*, &c. There are others also that condemn this *Hypothesis* as *Heretical* (as formerly that of the *Antipodes* was) and disconsentanious to several Places of *Scripture*; for they alledge. 1. That *Text* in Psalm. 104. 5. *He set the Earth upon her Foundations, so that it shall never move.* And, 2. Psal. 24. 2. *He hath founded it upon the Seas, and established it upon the Floods*; and several other Texts. And for the *Motion* of the *Sun*, they alledge; 3. *Ecclesiast.* 1. 5. Were it is Written, *The Sun ariseth, and the Sun goeth down, and hasteth to his Place where he arose.* Also, 4. Psal. 19. 5, 6. Where the *Psalmist* speaking of the Sun, he saith, *Which is as a Bridegroom coming out of his Chamber, and Rejoyceth as a strong Man to Run his Race. His going forth is from the end of the Heavens, and his Circuit unto the ends of it; and there is nothing hid from the Heat of it*: But in *Answer* to these Texts, or any other quoted in the *Sacred Volume*, take this pithy Answer of St. *Augustine*, who saith, *If any one shall object the Authority of Sacred Writ, against clear and manifest Reason; he that doth so, knows not what he undertakes; for he Objects against the Truth, not the Sense of the Scripture, which is beyond his Comprehension: Not what is in it, but what finding it in himself he fancied to be in it.*

Now

Now to conclude this Diſcourſe; for thoſe that deſire to make farther Scrutiny into this *Hypotheſis*, I would have them to Read (beſides the above named *Authors*) Dr. *John Wilkins*, late Lord Biſhop of *Cheſter*, his Learned *Diſcourſe* concerning a New PLANET, tending to prove, that 'tis probable our EARTH is out of the PLANETS; Wherein he inſiſts upon theſe following Particulars; *Viz.*

I. That the ſeeming Novelty and Singularity of this Opinion, can be no ſufficient Reaſon to prove it Erroneous.

II. That the Places in Scripture which ſeem to intimate the Diurnal Motion of the Sun, or Heavens, are fairly capable of another Interpretation.

III. That the Holy Ghoſt in many places of Scripture, does plainly conform his Expreſſions to the Error of our Conceits; and does not ſpeak of ſundry things as they are in themſelves, but as they appear unto us.

IV. That divers Learned Men have fallen into great Abſurdities, whilſt they have looked for the Grounds of Philoſophy from the Words of Scripture.

V. That the Words of Scripture, in their Proper and ſtrict Conſtructions, do not any where affirm the Immobility of the Earth.

VI. That there is not any Argument from the Words of Scripture, Principles of Nature, or Obſervations in Aſtronomy, which can ſufficiently evidence the Earth to be in the Center of the Univerſe.

VII. 'Tis probable that the Sun is in the Center of the World.

VIII. That there is not any ſufficient Reaſon to prove the Earth incapable of thoſe Motions which *Copernicus* aſcribes unto it.

IX. That it is more probable the Earth does move, than the Heavens.

X. That this Hypotheſis is exactly agreeable to common Appearances.

# CHAP. IX.

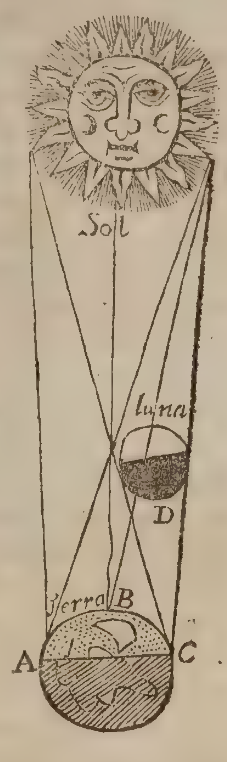
*Of the* Eclipses *of the* Sun *and* Moon, *the causes of them, and how and when they happen.*

## I. *Of the Eclipse of the* SUN.

THE Eclipse of the Sun is nothing else but the direct Interposition of the body of the Moon between our sight and the Sun, for the Moon being a dense, solid, and opacious Body, and not transparent, coming betwixt the Sun and the Earth, (which is always in a conjunction) doth thereby hide more or less of the Suns bright shining Body from our sight; but yet the Sun is not Eclipsed in every conjunction, but when it falleth in, or near to the Head or Tail of the Dragon. And it may sometimes so fall out, that the Sun may suffer two Total and Central Eclipses in the space of 6 months, one of which happening before the Suns Apogæon, and the other after, in which case there may happen no Full Moon Eclipsed that Year, according to the Rule: *Fieri potest ut duo interlunia nodis proxima & ferè centralia unius semestris intervallo accidant; unum quidem ante solis Apogæum, alterum post illud; quo casu intra totum annum lunarem nullum continget plenilunium Eclipticum.* But it cannot be Universal (as the Moons Eclipse is) but may appear in one Climate a great Eclipse, in another it may be lesser, and in other some no Eclipse at all, and that at the self same Instant, because the Eclipse of the Sun dependeth principally on the Parallax of the Moon, which is different in every Climate, (as hereafter, God willing, in another Work) and seeing that the Sun far exceedeth the Earth in bigness, and the Earth far exceedeth the Moon, therefore the Cone of the Earths shadow cannot take away, or hide the whole body of the Sun from all parts of the Earth; but one part only shall observe the same to be total, or of the like quantity. Hence it may appear that the Sun loseth no Light, but only we are deprived of the same by the interposition of the Moons Terreneal Body, (as is said before) and therefore Astronomers define, that it is *Interceptio luminis solaris profecta ex interpositu Lunæ inter solem atque aspectum nostrum.* So that *Suidas* well observes, That *solis Eclipsis fit, quando Luna in ipsum incurrit*; and for the better understanding of what is said, behold this Figure following.

A Type

*A Type of the* Sun's *Eclipse according to* Ptolomy.




By this Type it appears, that to him that ſtands in C, the whole body of the Sun is hidden from his ſight; to him that ſtands in B, half the Sun is only hidden; but to him that dwelleth in A, there is no part of the Sun hid from his ſight. Now there are ſome that think, that in the ſpace of 19 years all the Lunations and Eclipſes return again to their old courſe, and happen the ſame again: And of this Opinion is *Pliny*, in the 2d Book 13th Chap. of his *Natural Hiſtory*, where he ſays, *Elapſis ducentis viginti duobus menſibus Eclipſes in orbes ſuos redire.* Now ſome there be, who ſays that *Pliny*'s meaning was, That all the variety of Eclipſes are finiſhed in that ſpace of time. But this is but an Idle gloſs; for albeit in the ſame ſpace of time, the Head of the Dragon goeth once about the Zodiack, and the Eclipſes may happen thereby near the ſame time and place again, yet notwithſtanding they are not therefore the ſame, that is to ſay, of the ſame quantity and duration; for certain is the Rule, *Cæli motus inter ſe ſunt incommenſurabiles, nec unquam Phænomena eodem prorſus modo recurrere poſſunt.*

## II. *Of the Eclipſe of the* MOON.

THE Moon having no Light but what ſhe receiveth of the Sun, can never be Eclipſed but at the Full, but when ſhe is Diametrically oppoſite to the Sun, and the Earth, in the midſt between them both. Hence the Philoſophers rightly defined it, that is, *Privatio Luminis in Luna orta à diametrali terræ inter Solem & Lunam oppoſitione.* And *Lucan* alſo, *Lib.* 1. *Pharſal.* ſheweth the cauſe of the Moons Eclipſe.

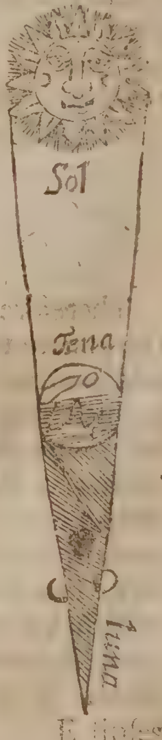
*——cornuque coacto,*
*Jam Phœbe toto cum redderet orbe*
*Terrarum ſubita percuſſa expalluit umbra.*

Therefore the Moon being full of Light, and exactly oppoſite to the Sun in the Head or Tail of the Dragon, may be totally Eclipſed, and deprived of Light by the ſhadow of the Earth; for the Earth being a thick and ſolid Body, caſteth its ſhadow to that part which is oppoſite to the Sun (whom it is that enlightneth the Moon, and all the Ætherial Region (*ſuo Lumine*) unleſs that point oppoſite to him.) When therefore the Moon at her Full, and oppoſition to the Sun, entreth into that obſcure part, on which the ſhadow of the Earth falleth, ſhe doth thereby loſe the Suns Light, and is obſcure and dark; which we call an Eclipſe. And here obſerve and be aſſured, that there is no Star whatſoever that can enter this ſhadow but the Moon alone, in regard of her propinquity to the Earth, for it is gathered

by sundry Observations made by the best Astronomers, that the shadow of the Earth is Conical the quantity of the extent (*a centro Terræ*) being 250 Semi-diameters, and the Moon being farthest remote in *Apogæo*, is distant from the Earth but 58 Semi-diameters ; from hence therefore it appears, that the Moon may enter into the said shadow, but not any of the other Planets ; and although *Venus* and *Mercury* are sometimes within the said limits, yet they are always nigh the Sun, and are never opposite to him ; so that this Massy Globe of the Earth can never interpose thereby, to hide the Suns glorious Beams from them. As for *Mars*, he is (in his mean motion) from the Earth 1745 Semi-diameters ; to which place the Cone of the Earths shadow never extendeth. And although the Moon is opposite to the Sun every month, she is not therefore Eclipsed in every opposition but then only, when at the opposition she is found in or near the Ecliptick, having then little or no Latitude.

Moreover, the Astronomers (the better to measure the quantity of the Eclipse) do divide the Diameter as well of the Sun as of the Moon, into 12 equal parts, which they call Points or Digits, and the more Digits the Eclipse is, the greater is the Eclipse. Yet in the Eclipses of the Moon, we must know that the Diameter of the shadow is far greater than the Diameter of the Moon. Hence the Moon, being in the middle of the said shadow which answereth the Line of the Eliptick exactly, the whole body of the Moon is not only obscured 12 Digits, but the obscuration is inlarged much by the plunging of the Moon (as it were) into the said dark shadow, and her long continuance there ; and therefore in Lunar Eclipses, we reckon the number of Digits according to the quantity of the shadow of the Earth, which may sometimes extend to almost 23 Digits.

*A Type of the* Moon's *Eclipse according to* Ptolomy.




Wherefore we usually reckon three sorts of Eclipses, the first partial, when her whole Body is not darkened, but some part thereof. The second, when her whole Body is darkened exactly ; and this is called a total Eclipse, but without continuance. The third, when she happens into the shadow of the Earth more than 12 Digits ; and this is called a total Eclipse with continuance, or stay in darkness : All the difference whereof ariseth principally from the Latitude of the Moon, and her distance from the Ecliptick Line. But of these things (*Deo permittente*) more amply hereafter in another Work.

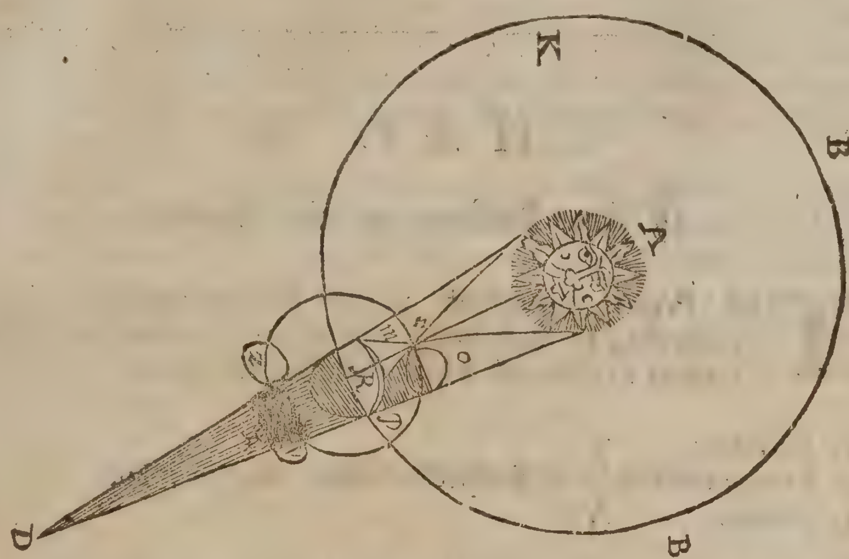
In this Diagram you may observe when the Eclipse is total, when partial, and when there is none at all in the opposition.

*More concerning the* Eclipses.

The two foregoing Schemes declare the reason of the

Eclipſes of the Sun and Moon according to the *Ptolomean* Syſtem, where the Earth is ſuppoſed to be the Center of the Univerſe: But this Scheme demonſtrates the ſame by the *Copernican* Syſtem, where the Sun is ſuppoſed to be the Center of the Univerſe, in which Scheme or Figure,

*A Type of the* Sun *and* Moon'*s Eclipſe according to* Copernicus.




## I. *For the* Eclipſe *of the* Sun.

A, Repreſents the *Sun*, and Center of the *World*.
B, K, R, *B*, The *Annual Orb* of the *Earth*.
R, The *Body* of the *Earth*.
S, Z, V, S, The *Orb* of the *Moon*.
O, The place of the *Moon* when ſhe is in *Conjunction* with the *Sun*.
V, X or Z, Her *Place* when ſhe is in *Oppoſition*.
D, The *Conical Point* of the *Earths Shadow*, which is *greater* or *leſſer*, according to the diſtance of the *Earth* from the *Sun*.

Now, by this *Figure* it appears, that to him that ſtands upon the *Earth* at N, the whole Body of the *Sun* is hidden from his ſight by the interpoſition of the *Moon* at O. But to him that is at R, there is but half the *Sun* obſcured. And laſtly, To him that lives at M, there is no part of the *Suns* Body hid from him ; but he, at the ſame Inſtant, may behold his whole Body free from any interpoſition of the *Moon*, as is plainly repreſented in the *Figure*.

## II. *For the* Eclipſe *of the* Moon.

When the *Moon* is in exact *Oppoſition* to the *Sun*, and void of *Latitude*, as ſhe is when placed at X, for then the Center of the *Earths* Shadow, whereby ſhe loſeth the whole Light of the *Sun*, by the direct interpoſition of the *Earth* between the *Sun* and *Her* ; whereby *She* is totally

tally *Eclipsed* with *Contrivance*: But if she be in the Points V or Z; then her *Eclipse* is *Partile*; and only a *Part* of her *Body* is darkned; and if her *Latitude* (at the time of her *Opposition* with the *Sun*) be so great *Northward* or *Southward*, that it be out of the Verge of the *Cone* of the *Earths Shadow*, as at C or D. Then she is free from all obscurity thereby, and so suffers no *Eclipse* at that *Opposition*: All which Positions the *Figure* plainly Demonstrates.

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## CHAP. X.

### *Of some* Passions *of the* Planets.

I. THE *Planets*, in respect of that Motion which they make, according to their Longitude in the *Ecliptick*, are subject to several *Passions*, of which these are the Chief.

1. *Direction.*
2. *Retrogradation.*
3. *Station.*

} In Respect of their *Motion*; For

First, A Planet is said to be *direct* in Motion, when it moveth forward, agreeable to the Order and Succession of the *Signs*; as from *Aries* to *Taurus*, *Gemini*, &c.

Secondly, A Planet is said to be *Retrograde* in Motion, when its Motion is contrary to the Order and Succession of the Signs; as when a Planet moveth from *Cancer* to *Gemini*, and so to *Taurus*, &c.

Thirdly, A Planet is said to be *Stationary*, when in its change between *Direction* and *Retrogradation*, the change is not in a small time perceptible, and seemeth to continue in the same place for some days together; and so is said to be *Stationary*.

II. The Planets among themselves, in respect of their Longitudes in the *Ecliptick*, are subject to several *Aspects*, as principally these five.

1. *Conjunction.*
2. *Opposition.*
3. *Trine.*
4. *Quartile.*
5. *Sextile.*

First, *Conjunction* is when any two Planets are in one and the same *Sign* and *Degree* of the *Ecliptick*, as if *Saturn* be in 16 deg. of *Gemini*, and *Mars* be there also; then there is said to be a *Conjunction* of *Saturn* and *Mars*, which the Astronomers do thus Characterize ☌ ♄ ♂.

Secondly, *Opposition* is when any two Planets are in opposite *Signs* of the *Ecliptick*, or are just *six Signs*, or a half Circle, distant from each other; as if *Jupiter* be in 10 deg. of *Aries*, and *Venus* in 10 deg. of

of *Libra*, then there is said to be an *Opposition* of *Jupiter* and *Venus*, which is thus expressed in Characters ☍ ♃ ♀.

Thirdly, *Trine*, Two Planets are said to be in *Trine*, when they are four Signs (or one third part of a Circle, which is 120 deg.) distant from each other. As if the Sun be in 25 deg. of *Taurus*, and *Mars* in 25 deg. of *Virgo*, then there is a *Trine* of the *Sun* and *Mars*, which they thus express △ ☉ ♂.

Fourthly, *Quartile*, Two Planets are said to be in *Quartile Aspect*, when they are distant from each other *three Signs* (or one *Quadrant*, or quarter of the *Ecliptick*, which is 90 deg. distant from each other,) as if the *Moon* be in 6 deg. of *Pisces*, and *Mercury* in 6 deg. of *Gemini*, then there is a *Quartile Aspect* between those two Planets, and is thus Characterized □ ☾ ☿.

Fifthly, *Sextile* is when two Planets are two *Signs* in the Ecliptick distant from each other; as if *Saturn* be in 12 deg. of *Cancer*, and *Jupiter* in 12 deg. of *Virgo*, then do those two Planets make a *Sextile Aspect*, and are thus expressed in Characters ⚹ ♄ ♃.

*Venus* and *Mercury* cannot make any of these Aspects with the Sun. Neither can *Venus* and *Mercury* make any of them between themselves, except the *Sextile*, which they often do.

III. The Planets Places in the *Ecliptick*, being compared with the *Suns* Place, they are either,

1. *Combust.*
2. *Oriental.*
3. *Occidental.*

First, A Planet is said to be *Combust*, when it is so near the *Sun*, that it cannot be seen, by Reason of the *Suns* Bright Rayes.

Secondly *Oriental*: A Planet is said to be *Oriental*, when it Rises in the Morning, and may be seen in the *East* before the *Sun* Rises.

Thirdly *Occidental*: A Planet is said to be *Occidental*, when it may be seen in the *West* some time after the *Sun* is set.

IV. Of the *Poetical* Rising and Setting of the *Stars* and *Planets*, and they are principally three, *Viz.*

1. *Cosmical.*
2. *Acronical.*
3. *Heliacal.*

First, A *Star* or *Planet*, is said to *Rise Cosmically*, when it *Riseth* with the *Sun*, or with that degree of the *Ecliptick* in which the *Sun* then is: And it is said to *set Cosmically* when it *setteth* in the *West* in the *Morning*, at such time as the *Sun* is Rising in the *East*.

Secondly, A *Star* or *Planet* is said to *Rise Acronically*, when it *Riseth* in the *East* Horizon, at such time as the *Sun* is going down in the *West*: And the *Acronical setting*, is when a *Star* or *Planet* goeth down, or *setteth* with the *Sun*.

Thirdly, A *Star* or *Planet* is said to *Rise Heliacally*, when having been some time *Combust* (or hidden under the *Sun* Beams) begins to appear: And *Heliacal setting* is some small time before it comes to be *Combust*.

Now

Now to know when a Star or Planet begins to become Combuſt, and when to be freed from his Combuſtment of the Suns Beams, no certain Rule can be given; for the Magnitude of the Star; the Difference of the Climate; the Cloudineſs or Serenity of the Air may much alter: But the Opinion of the Ancient Aſtronomers was; That

| | | | | |
|---|---|---|---|---|
| A Star of the | Firſt | Magnitude may be ſeen, when the Sun is but | 12 | Degrees below the Horizon. |
| | Second | | 13 | |
| | Third | | 14 | |
| | Fourth | | 15 | |
| | Fifth | | 16 | |
| | Sixth | | 17 | |

But thoſe which are only Nebulous cannot be ſeen until the Sun be 18 Degrees below the Horizon.

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## CHAP XI.

*Containing the Rudiments of Aſtronomy, put into plain Rhyme, by Mr.* John Palmer, M. A.

### I. Of the Circles of the SPHERE.

SIX Great Circles *mark you ſhall*;
*Which* Equally *divide this Ball*:
*Juſt in the midſt, between the* Poles,
*From* Eaſt *to* Weſt *th'* Equator *Rolls*,
*Th'*Ecliptick *cuts him, and doth ſlide*
*Scarce* Twenty Four *Degrees aſide:*
Horizon *even with the Ground*,
*From* Stars *below our ſight doth bound*:
Meridian *Upright doth Riſe*,
*Parting the* Eaſt *and* Weſtern Skies:
*Two* Colures *through the* Poles *do Run*,
*Quart'ring the* Circle *of the* Sun,
*One where the* Spring *and* Fall *begin*,
*Th'other where* Longeſt Days *come in*.

*Four* Leſſer Circles *(Mark them well)*
*Are to th'*Equator *Parallel:*
*Two* Tropicks *Bound the* Sun's *High-way*,
*Shewing the* Longeſt *and* Shorteſt *Day*:
*The* Arctick Circle *cuts the* Bears,
*Th'*Antartick *Oppoſite Appears*.

Meridians

Meridians *half Twenty Four,*
*For* Hours, *and for* Degrees, *Nine Score,*
*Through both* Poles *of the World do paſs,*
*And th'* Equinoctial *downright croſs*;
*And Nine Score* Parallels *hath that Line,*
*By which* Stars North *and* South Decline.
*Th'*Ecliptick *hath his* Longitudes,
*And* Parallels *of* Latitudes
*For* Stars; *but in* Geography,
*The* Towns *beſide th'* Equator *lie.*

*Over our* Head, *and under* Feet,
*The Nine Score* Azimuths *do meet*;
*And here as many* Parallels
*Of* Altitude Horiſon *tells.*

Longitudes *and* Meridians *all,*
*And* Azimuths Great Circles *call*;
*But all their* Parallels *in Heaven*
*Being* leſſer, *cut the* Globe uneven.
Degrees *Three Hundred and Three Score,*
*Hath every* Circle; *and no more.*

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## II. Of the Conſtellations of the Fixed Stars.

THE *Army of the Starry Sky,*
*Declare the Glory of God moſt high*;
*Seen and perceived of all Nations,*
*In Eight and Forty* Conſtellations.

Firſt, *Near unto the* Northern Pole,
*The* Dragon *and two* Bears *do Roll,*
*Whoſe hinder Parts and* Tails *contains*
*The leſſer and the greater* Wains:
*The* Hare, *the* Bearward, *and the* Crown;
*And then comes* Hercules *kneeling down*;
*And next below a place doth take,*
*Great* Serpentarius *with his* Snake,
*Under the* Harp *of* Orpheus,
*The* Eagle *and* Antinous;
*The Silver* Swan *her Wings doth ſpread*
*Above the* Dart *and* Dolphins *Head*;
*Then* Pegaſus *comes on amain,*
Andromeda *follows in her* Chain;
*The* Triangle *below her ſtands,*
*And at her Feet is* Perſeus *Hands.*

*The* Gorgons Head *above are ſeen*
*Her Parents*, Cephus *with his* Queen
Caſſiopea: *Not far below*
Heniochus *his* Goat *doth ſhew*
*On his Left* Shoulder, *in his Hand*
*He doth the Stormy* Kids *Command.*

*Here in the* Zodiack *begins*
*The* Lamb, *the* Bull, *the Loving* Twins;
*The* Crab, *the* Lion, *and* Virgin *Tender*,
*The* Ballance, Scorpion *and* Bow bender;
Goat, Waterman *and* Fiſhes *twain*,
*Shall bring you round to th'* Rain *again.*

*Fifteen* Images *appear*
*In the* Southern Hemiſphere;
*The Monſtrous* Whale *before the reſt*,
Eridanus *ſcarce wets his Breaſt*;
*Over the* Hare, Orion *bright*
*Sparkles in a Winters Night*;
*Then comes the* Great Dog *at his Tail*,
*And famous* Argo *ſpreads his Sail*;
*Above the* Little Dog *doth flame*,
*For whom the* Latines *had no Name.*
*Long* Hydra *on her* Tail *a-low*
*Carries the* Pitcher *and the* Crow;
*The* Centaur *holds the* Wolf *by th'* Tail;
*The* Altar *and* Ixions Wheel
*Are never ſeen of us*; *But here*
*The* Southern Fiſh *brings up the Rear.*

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## III. Of the Seven Planets.

U*Nder thoſe* Fixed Stars *above*
Seven Planets *in their* Orbs *do move.*
*The high'ſt is* Saturn; *Thirty Year*
*He ſpends in Compaſſing his Sphere.*
*Twelve* Jupiter; *and* Mars *in twain*
*Sets forward, and comes round again.*
*Then in one Year the* Sun *diſplays*
*Three hundred Sixty and Five days*;
*And near a Quarter, which in Four*
*Encompaſſing, makes one Day more.*
*Between the* Sun *and us there fly*
*Fair* Venus *and ſwift* Mercury.
*Theſe always near the* Sun *we find,*
*Not far before, nor far behind.*

The

*The* Moon's *the lowest, who in Seven*
*And Twenty Days goes round the Heaven;*
*And above two Days more does Run,*
*Before she overtakes the* Sun:
*So Twenty Nine Days and an half in all,*
*Do make a* Month Synodical.
*These* Planets *make their Course to th'* East,
*Though they be faster hurled* West;
*And* Six Degrees *the rest may stray,*
*Besides the* Suns *Ecliptick way.*

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SANDYS upon *Psal.* 8.

*WHen I, pure Heav'n, thy Fabrick see,*
*The* Moon *and* Stars *create by thee;*
*O! what is Man, or his frail Race,*
*That thou should'st such a shadow grace?*

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## CHAP. XII.

*Of the* Constellations *of the* Fixed Stars, *Giving an Account of their* English, Greek, Hebrew, Latine, Arabick, Caldee, Syriack, Turkish, *&c.* Names; *and of the most Eminent* Stars *in each of them: With the* Poetical Fables; *declaring how these* Asterisms *came to be placed in the* Heavens; *and also of the* Galazia.

### I. Of the Zodiacal Constellations.

#### *ARIES.*

THis Sign is called by the Greeks Κριὸς *Chrysomollus, Jupiter Ammon*; by the Ægyptians or Copties *Tametouro Ammou*, i. e. *Regnum Ammonis*; in Hebrew *Tele*; in the Syriack *Emro*; by the Arabians *Al Hámal*; by the Persians *Bèrri*, or *Bére*; by the Turks *Kazi*: All signifying a *Lamb full grown.* In this *Constellation* are reckon'd 17 Stars, whereof 4 *informes*, i. e. Placed without the Figure. This, according to the Tradition of the Ægyptians, was made a *Constellation* in Honour of *Cham.* But as *Nigidus*, for discovering to *Bacchus*, and his thirsty Army in the Desarts of *Africa*, a Fountain of Water; Or, as *Pherecides*, for transporting of *Phryxus* and *Helle* over the Sea;

 flying

flying from their Step-Mother *Ino*. *Schillerius* will have this Conſtellation Attributed to St. *Peter*; and *Schickardus* to *Abrahams* Ram, offered in the Room of *Iſaac*. This *Sign* was firſt diſcovered by *Cleaſtratus* and *Tenedian*; and it comes to the Meridian at Midnight, about the end of *October*, and beginning of *November*.

## TAURUS.

THis Sign is called by the Ægyptians, *Jo*, *Iſis*, *Apis*, and *Orias* i. e. *Statio Hori*; by the Greeks and Latines, Ταῦρος and *Taurus*; in Hebrew, *Shór*; by the Arabians, *Al Taur*; by the Syrians, *Thauro*; by the Perſians, *Ghau*; and by the Turks, *Ughuz*, *i. e.* Bos.—— This *Conſtellation* conſiſts of 44 Stars, whereof 11 ſhapeleſs: Of theſe there is one of the firſt Magnitude, called by the Greeks λαμπαδίας; by *Ptolomy*, ὑπόνυϛερος; by the Arabs *Aldebaran*, i. e. *Stella Dominatrix*, and *Ain Al Thaur*, i. e. *Oculus Tauri*; by the Ægyptians, *Piorion*, i. e. *Statio, ſeu Dominium Hori*; in regard of the Power of the Sun in Conjunction with that Star; by the Romans *Palilicium*, becauſe heretofore it roſe at *Rome* on the Feaſt Day of *Pales*—— It was Tranſlated into Heaven in Memory of the Raper of *Europe* by *Jupiter* in that ſhape; or in Honour of *Jo*, or *Iſis* Transformed by *Juno* into a *Cow*, and *Conſtellated* by *Jupiter*. Others will have it to be the Symbol of *Oſyris* or *Meſoris Mizraim*, the Son of *Cham*, who firſt taught the Ægyptians *Tillage*; or rather, of the Patriarch *Joſeph*, for his preſerving *Ægypt* in the time of Famine. *Schillerius* will have this Conſtellation Attributed to St. *Andrew*; but *Harſdoſius*, to the *Offering* of *Burnt-Sacrifice* commanded, *Levit.* 1. 3. About the end of *November*, and beginning of *December*, this *Conſtellation* may be ſeen upon the Meridian at Midnight.

## GEMINI.

THoſe are called by the Greeks and Latines Δίδυμοι, *Tindaridæ* and *Dioſcuri*; in the Coptick, *Cluſos*; i. e. *Cluſtrum Hori*; in the Hebrew *Termin*; in Syriack, *Tóme*; in Arabick, *Taw Amân*, i. e. *Gemelli*; they are likewiſe by the Arabs called *Giauzu*; others derive it from *Gianz*, ſignifying a *Nut*; and therefore the Turks call this Sign Kōs *Siphetlu Burgi*, i. e. *Nucem, vel Nuces referens Signum*; by the Perſians *Ghirdegân* to the ſame ſenſe. There are reckoned in this *Conſtellation* 25 Stars, whereof 7 Informes: The Star in the Head of the Weſtern *Twin* is called by the Arabs *Ras al Tawum Almukeddem*, i. e. *Caput prioris Geminorum*; the other, *Ras al Tawum Munaccher*, i. e. *Caput poſterioris Geminorum*: The two Stars oppoſite one to the other in the *Feet* of the ſaid *Gemini* are by the Arabs called *al Hen'a*; *Varro* will have them to be *Apollo* and *Hercules*; others will have them to be *Triptolemus* and *Jaſon*; ſome *Amphion* and *Zethus*: But with greateſt probability they are conceived to be *Caſtor* and *Pollux*; Δοκανά, i. e. *Trabalia*, being no other than *two Wooden Poſts ſet parallel one to another*, *and joyned together at each end by two other tranſverſe Beams*. Hence, ſaith the Learned *Palmerius*; Aſtrologers make uſe of the like *Figure* or *Character*, to denote this *Twyn Sign*; which they derived

from

from the *Lacedemonians*—— *Schillerius* will have this *Constellation* to signifie St. *James* the Elder; but *Schickardus*, *Jacob* and *Esau*—It comes to the Mid-Heaven at Midnight, in the end of *December* and beginning of *January*.

## CANCER.

THis Sign is in the Greek called Καρκῖνος and Οκταπυς, i. e. *Octipes*, it is likewise called *Nepa Astracus*, *Camarus*; in Arabick, *Alsertem*; in Hebrew *Sartan*; in Syriack *Sartóno*; in Persian *Chercjengh*; by the Turks *Lenkutch* or *Lenkitch*; and *Yenkutch*, or *Yenkitch*, and *Yilenkutch*, or *Yilenkitch*; i. e. *Cancer*; in the Coptick it is called *Klaria*, i. e. *Bestia, seu statio Typhonis.* The whole Constellation is made up of 13 Stairs, of which 4 shapeless. Amongst which the first Star is called in Arabick *Malaph*, i. e. *Præsepe*, or the *Mainger*; in Greek Φάτνη; it is likewise by the Arabs called *Al Nethra*; in Chaldie *Pesebre*; and it is a *Cloudy Star*; by *Galileus* discovered to consist of 36 smaller ones——This *Crab* was made a *Constellation* at the Intreaty of *Juno*, being kill'd by *Hercules*, for biting him by the Foot, when he encountred *Hydra.* The *Asinegces* with their *Mainger*, were *Constellated*, because of the Fight with the Gyants, *Baccus* and *Vulcan* charged upon *Asses*, who with their Brayings Frighted, and so put to Flight their Enemies. *Schilerus* will have this *Constellation* ascribed to *St. John* the Evangelist.—— This *Sign* is Famous according to the *Chaldaick* and *Platonick* Phylosophy, for being supposed the *Gate* by which *Souls* descended into Humane Bodies. This *Constellation* may be seen about Midnight, almost all the whole Month of *January*.

## LEO.

THis *Sign* is by the *Greeks* called λέων; in Hebrew *Ar'ye*; by the Arabs *Al Asad*; in Syriac *Ar'yo*; in the Persian *Shir*; the Turks call it *Arslàn* or *Arslin*, i. e. *Leo*; the Ægyptian Copties call it *Pimentekeon*, i. e. *Cubitus Nili.* The Constellation consists of 39 Stars, whereof 8 inform. The first Star in this Constellation is by the Arabs called *Minchir al Asad*, i. e. *Nares Leonis*; The third *Ras al Asad, al Chemali*, i. e. *Caput Leonis Boreale*: The fourth *Ras al Asad, al Gienubi*, i. e. *Caput Leonis Australis*: The fifth, sixth and seventh Stars, are called by them *Gieb'ha*, i. e. *Frons*: The eighth they call *Melichi*, to which the Latine *Regulus* Answers. They give it likewise the Name of *Kalb al Asad*, i. e. *Cor Leonis*, being a Star of the first Magnitude. The seven and twentieth Star they call *Serpha*, i. e. *Mutatrix*, from the Change it brings of Heat from Cold; and *Danab al Asad*, i. e. *Cauda Leonis*, and is likewise of the first Magnitude. The *Lion* was made a *Cælestial Sign* by *Juno* to spite *Hercules*, by whom he was slain, and is said to have been bred in the *Moon*, and from thence to have fallen near the *Nemeæan Grove* in *Arcadia*, from whence called *Nemeæus*. *Schillerius* will have this Constellation attributed to St. *Thomas*, but *Schickardus* to *the Lion of the Tribe of Juda.* This Constellation will be seen in the Meridian at Midnight in the Month of *February*.

VIRGO.

## VIRGO.

THis *Constellation* in Greek bears the Name of παρθένος, to which the Latine *Virgo* Answers. In Hebrew it is called *Bethula*; in Syriac *B.thulto*; in Arabic *Adra* and *Adrenedepha*; and in the Persian *Dushiz á Pakiza*; all to the same sense with the former. In the Ægyptian or Coptick it is called *Aspholia*, i. e. *Statio Amoris*. It is likewise, in respect of the chief Star by which it is signified, being one of the first Magnitude in her Left Hand, called by the Hebrews *Shibboleth*, by the Syrians *Sh.volto*; by the Arabs *Súmbela*; by the Persians *Chûshe*; and by the Turks *Salkim*; all signifying a Spike or Ear of Corn. In this Constellation *Ptolomy* reckons 32 Stars, of which 6 inform. The sixth and seventh Stars in this Constellation are by the Arabs called *Min al Auwa, de latratore*; and so likewise the Tenth: The seventh is by them called *Zawija al Auwa*, i. e. *Angulus Latratoris*: The Thirteenth, which is also one of the first Magnitude in her Right Wing, called by *Proclus Prævindemiator*, is by the Arabs called *Mukdim al Ketaph*: The Fourteenth, which is the *Spica*, *Simak al A'zal*, i. e. *Efferens Inermem, Scil. Virginem*; to distinguish it from another Star in *Bootes* called *Simâk al Ramih*, i. e. *Efferens Hastiferum*. The 22d, 23d, 24th and 25th Stars are called *Min al Gaph'r*, i. e. *Ex al Gaphr*, which signifies *Velamen, Ventrem & Tecturam, quod Stellæ ejus obtectæ sint*. This Sign, according to the Vulgar Opinion, is taken for *Astræa*, or *Justice*; by others for *Erigone* Daughter of *Icarius*; others suppose her to be *Ceres*, *Quod spicas teneat*; others call her *Atergatis* the Goddess of the *Assyrians*; some will have her to be *Fortune*. *Avienus* makes her to be *Isis*; and others again will have her to be *Concord* or *Peace*. *Schillerius* attributes her to St. *James* the Younger; but *Schickardus* will have it the Virgin *Mary*. This Constellation visits the Meridian at Midnight about the end of *March*, and beginning of *April*.

## LIBRA.

THis *Asterism* is called by the Greeks λίτρα, σταθμὸς, στατὴρ καὶ Ζυγὸς; to which the Latine *Libra* Answers. By *Cicero* it is called *Jugum*, answering to the last of the Greek Names. In Hebrew it is called *Mozenáim*; in Syriack *Masátho*; in Arabick *Al Mizan*; by the Persians *Terazu*; all signifying *Libram, Stateram, seu Balancem*. The Turks use the Arabick Name *Mizan*, which in their Language is *Tartagick alati*, i. e. *Ponderandi Instrumentum*. In the Coptick it is called *Lambadia*, i. e. *Statio Propitiationis*. This Constellation is made up of Seventeen Stars, whereof Nine inform; among which, the first Star by the Greeks called χηλὴ Νότιος; is by the Arabs called *Zubána Gienubi*, i. e. *Chela Australis*, and *Al Kiffa*, *Al Gienubija*, i. e. *Lanx Australis*; The third Star called by the Greeks χηλὴ βόρειος, is accordingly called by the Arabs *Zubâna Shemâli*, i. e. *Chilo Borealis*, and *Al Kiffa al* Shemâlija, i. e. *Lanx Borealis*. There is no distinct *Fa-*

*ble* of this Sign, it being part of *Scorpius.* Yet *Schillerus* attributes it to St. *Philip* and *Hartsdorſius*, to the *Tekel* or *Ballance* of *Belſhaſar*, Dan. 5. 27. This *Aſteriſm* mounts the Meridian at Midnight about the beginning of *May*.

## SCORPIO.

THE Hebrews call this Sign *Akrab pro Akatzrab à magno oculo*: The Syrians call it *Aknevo*; The Arabs *Al Akrab*; The Perſians *Ghezdum*; The Turks *Koirughi*, *quaſi* Κατ' ἐξοχὴν, *Caudatus*, or *Uzun Koirughi*, i. e. *Longa Cauda præditus*; By *Cicero* it is called *Nepo*, which *Feſtus* ſays is an African Word; By the Greeks Σκόρπιος; and by the Ægyptians *Copties Iſias*, i. e. *Statio Iſidis.*—There are counted therein 24 Stars, whereof 3 Shapeleſs: The 6 firſt are by the Arabs called *Iclil al Gieb'ha*, i. e. *Corona Frontis*: The 6th is particularly called *Gieb'ha al Akrab Frons Scorpii*: The 8th is of them called *Kalb' al Akrab*, i. e. *Scorpii*, &c.——The *Scorpion* is Fabled to have been made a Conſtellation for having ſlain *Orion*, who boaſting he would in Hunting deſtroy all the Wild Beaſts in the Forreſt; Or, according to *Nigidius*, For that Hunting with *Diana* in the Mountain *Chillippius* in the Iſland *Chios*, he contemned and derided Her as inferior to him in Skill; Or, according to *Palæphatus* and *Nicandar* in *Theriac*, for daring to have violated her Chaſtity; for which, in Revenge, ſhe is ſaid to have ſent this *Scorpion* to Sting him to Death, as he was, for which, at her Requeſt, by *Jupiter* he was made an Aſteriſm, (*Schickardus* aſcribes it to St. *Bartholomew*) and is ſeen to crawl towards the Meridian of Midnight about the end of *May*, and beginning of *June*.

## SAGITTARIUS.

THis Conſtellation is in Hebrew called *Keſheth*; In Syriack *Keſhto*; in Arabick *Alkaus*; in the Perſian Tongue *Kaman*; in the Turkiſh *Yai*; all ſignifying an *Arrow*: In Greek τοξότης according to which ſignification it is likewiſe by the Arabs called *Rami*; by the Ægyptians *Pimaere*, i. e. *Statio Amœnitatis.*—— It conſiſts of 31 Stars, of which the firſt is by ſome of the Arabians called *Zugo al Nuſhaba*, i. e. *Cuſpis, vel Ferramentum Spiculi*: The 8th Star in this Conſtellation is by the Arabs called *Ain al Rami*, i. e. *Oculus Sagittarii*: The 23d *Urkub al Rami*, i. e. *Suffrago*, the Hough or Poſtern: The 24th *Rukba al Rami*, i. e. *Genu*, the Knee of *Sagittarius.*——*Hyginus*, from the Authority of *Soſitheus*, will have this to be *Crotus*, the Son of *Euphemis*, or *Euthemis*, the Nurſe of the Muſes, at their Inſtance, by *Jupiter*, placed in the *Zodiack*. Others will have him to be *Chiron*. This Sign, at Midnight, will be upon the Meridian about the end of *June*, and beginning of *July*.

CAPRICORN.

## CAPRICORN.

THE Greeks give to this Sign the Name Αἰγόκερως, ϰ̓ Αἰγίπαν; The Latines *Hircus Æquoris*: In Hebrew it is called *Gedi*; in Syriac *Gadio*; in Arabick *Al Giedi*; in the Persian *Buzeghale*; in Turkish *Uglack*; all signifying a Kid or Goat. In the Coptick or Ægyptian Tongue it is called *Hopeutus*, i. e. *Brachium Sacrificii*. It is made up (by the general assent of Astronomers) of 29 Stars, of which the first and third are by the Arabs called *Min Sad al Dabih*, i. e. *Ex fortuna Mactantis*; and simply, *Dabigh*, i. e. *Mactans*. The 23d and 24th Stars are called by them *Sad Nashira*, i. e. *Fortuna averruncantis, vel divulgantis Nuncium*; But the 24th, by a particular Name from its situation, is called *Danab al Grebi*, i. e. *Cauda Capricorni*.----This was made a Constellation in honour of *Ægipan* the Son of *Jupiter*, by the *Olenian Goat*, or rather his Foster-Brother, Son of *Æga*, the Wife of *Pan*, whence his Name; who as *Bassus*, in *Germanic*, from the Authority of *Epimenides* writes, assisted *Jupiter* in his Wars against the *Titans*, and Armed the Gods, and for that reason honoured with this Cœlestial Dignity. The reason of his being Figured half Goat half Fish, *Theon*, the Scholast of *Aratus* reports, was, That he finding on the Sea shore an empty *Murex*, or Purple Shell, is said to have wound it like a Horn, thereby striking a Panick fear into the *Titans*, and therefore they represented him with a Tail like a Sea Monster. Celebrated it is, according to the Doctrine of the *Pythagoreans* and *Platonists*, for being the Gate by which Souls ascend into Heaven, and therefore stiled *Porta Deorum*. *Schillerus* ascribes this Asterism to S. *Simon*: It ascends the Mid-heaven at Midnight about the end of *July*, and beginning of *August*.

## AQUARIUS.

THis Sign is by the Greeks called ὑδρόχοος, by *Appian*, *Hydridurus*; and in the same signification by the Arabs, *Sakib al Mâ*, i. e. *Effusor Aquæ*. It is by them likewise called *Al Delu*; and in Hebrew *Deli*; in Syriac *Daulo*; in the Persian Tongue *Dul*; in the Turkish *Kugha*; all signifying an Urn, or Watering-Pot. The Ægyptians or Copties call it *Hupeutheron*, i. e. *Brachium Beneficii*. There are reckoned therein, according to *Ptolomy* and *Kepler*, 45 Stars, whereof 3 inform. Of these Stars, the 2d and 3d are called in Arabick *Sa'd al Melick*, or *Sa'd al Mulck*, the first signifying *Fortuna Regis*, the latter *Fortuna Opum & Substantiæ*. The 4th and 5th are called *Sa'd al Sund*, i. e. *Fortuna fortunarum*; under which are some other Stars of less Note, called *Al Ana*. The 6th and 7th are called *Sa'd Bula & al Bulaan*, i. e. *Fortuna Delutientis*, or *Delutientium*. The 9th, 10th, and 11th Stars are called *Sa'd al Abbija*, i. e. *Fortuna Tentoriorum*: The 14th Star in this Constellation being one of the first Magnitude,

is in Arabick called *Diphda al Auwal*, i. e. *Rana prima*. It is likewise called *Phom al Haut al Gienubi*, i. e. *Os Piscis Australis*, and commonly, but corruptly. *Phomahant*. This Asterism is by some Fabled to be *Ganymede*, the Cup-bearer of *Jupiter*; by some *Deucaleon*: (whence by *Vomanus* this Sign is Intituled *Deucalionis Aquæ*) By others *Aristæus*. By *Schillerus* this Sign is attributed to St. *Jude*, but by *Schickardus* to *Naaman*, 1 Reg. 25. 14.——It is seen in the Meridian at Midnight, about the end of *August* and beginning of *September*.

## *PISCES.*

THis Sign in the Greek is called Ἰχθύων ἀπεισμός, and by the Jews accordingly, *Dagaim*, i. e. *Duo Pisces*; but the Arabs call it *Al Haut*, *& al Samaca*; the Syrians *Nano*; the Persians *Mahi*; the Turks *Balick*; which signifies a *Fish* in the singular Number; so likewise in the Coptick it is called *Pikotoron*, i. e. *Piscis Hori*. The *Northern* of these *Fishes* is in the Arabick called *Haut Alshemali*, i. e. *Piscis Borealis*, and is known by the peculiar Name of χελιδονίας, as being represented by the Chaldeans with the Head of a *Swallow*; the reason, as *Scaliger* conceives, because when the Sun is in this Sign, the Swallow begins to appear in those Regions: The *Southern* is called *Haut al Gienubi*, i. e. *Piscis Australis*. The whole Constellation consists, according to *Ptolomy*, of 38 Stars, whereof 4 inform. The *Stream*, or *Tenuis fusio Stellarum utriusque Piscibus disposita*; *Vitruvius* calls *Mercurii Domum seu* Delicias, which *Scaliger* conceives ought to be read *Lagneam*; or as *Pliny* terms it, *Commissuram Piscium*. The Arabians call it *Cheit*, *vel Cheit Kottani*, i. e. *Filum Linteum*.——These are Fabled to be the *Syrian* Deities, according to *Germanicus*, *Syriæ duo Numina Pisces*; by which are understood *Venus* and *Cupid*, as *Hyginus* (from the Authority of *Diognetus Erythræus*) writes. For *Venus*, and her Son *Cupid*, coming to the River *Euphrates*, and frighted at the sudden appearance of the Giant *Typhon*, cast themselves into the River, and assumed the shapes of Fishes, by which means they escaped from danger: For this reason the Syrians abstain from Eating of Fish, lest they might happen to Eat up their Deities: But the Scholiast of *Germanicus* (from *Nigidius*) writes, That these were the Fishes which turn'd or roll'd up upon the Bank of *Euphrates* a great Egg, upon which a Dove sitting, Hatch'd *Venus*, the Syrian Goddess. *Schillerus* will have these attributed to St. *Matthias*; but *Schikardus* to the two Fishes in the Gospel, *John* 6. 9.——This Asterism may be seen in the Meridian at Midnight, almost the whole Months of *September* and *October*.

## II. Of the Ancient Northern Constellations.

### HELICE.

SO Named by the *Greeks*; it is alſo called *Urſa Major*, &c. *Plauſtrum Majus*; in Arabick *Dub Ackber*; it is likewiſe by the *Arabs* called *Benât al Noſh al Cubra*, i.e. *Filiæ feretri Majoris*, in regard the 4 Stars that make the *Body* of the *Bear* reſemble a *Bier*, and the Three in the *Tail*, the *Virgins* or *Maids* that Attend the *Corps*: And for this Reaſon, the Chriſtian *Arabs* call the four Stars *Naſh Laâzar*, i. e. *Feretrum Lazari*, and the Three in the Tail, *Mary Magdalen*, *Martha* and their Maid; by the Perſians it is called *Haphtûrengh Mihîn*, i. e. *Septentrio Major*; and by the Turks, *Yidigher Yilduz*, i. e. *Septenæ ſtellæ*, and by the Latins, *Septem Triones*. This Conſtellation conſiſts of 35 Stars, whereof 8 inform. Of theſe Stars the 12 and 13 are called in Arabick *al Nekra al Thâlitha*, i. e. *Cotyle*, *Scrobs ſeu Cavitas oſſis Tali*; the 16 *Dubr al Dub al Ackber*, i. e. *Dorſum Urſi Majoris*; the 17 *Mrâk al Dub al Ackber*, i. e. *Epigaſtrium Urſi Majoris*; the 18 *Mg'res al Dub al Ackber*, i. e. *Uroxygium Urſi Majoris*; the 19 *Phaid al Dub al Ackber*, i. e. *Femur Urſi Majoris*; and theſe four laſt Named make up *al Na'ſh al Cubra Feretrum Majus*. The 20 and 21 are called *al Phikra* or rather *al Nekra, al Thanija*, i. e. *Vertebra ſeu Cotyle ſecunda*; the 23 and 24 *al Nekra al Ula*, i. e. *Vertebra ſeu Cotyle prima*. The three Stars that make the *Tail* are called, *al Benât*, i. e. *Filiæ*; whereof the firſt is called *al Haun*, ſignifying *album Nubiculum*; the ſecond is called *al Inâk*, or *al Anâk*, i. e. *Capella*; the third *Alkaid*, i. e. *Gubernator*. This *Conſtellation* was firſt found out by *Naupilus*, and was Anciently the *Greek* Sea-Mens Guide; as the Leſſer the *Phænicians*: The Reaſon is, becauſe to the *Greeks*, who Sailed the *Mediteranean*, *Pontick* and *Euxine* Seas, this *Conſtellation* was ſtill apparent: But to the *Sydonians*, *Phœnicians* and *Carthagenians*, who were more Southerly, part of the *Greater* Bear was either by the Poſition of the Sphere, or ſome other Accident, ſometimes depreſt, or obſcured; but *Cynoſura* always appeared to them: And therefore, theſe laſt choſe the *Leſſer*, and the *Greeks* the *Greater Bear* for their *Directreſs*.

*Schillerus* Attributes this Conſtellation to St. *Michael*; but *Hartſdorſius* to one of *Eliſa's Bears*, 2 *Reg.* 2. 24. Or the Wagon of *Jacob*, or Chariot of *Joſeph*, *Gen.* 45. 27, &c. 46. 29.

### CYNOSURA.

SO called by the Greeks, *quaſi Canis Cauda*; the Hebrews call it *Genaſh*, i. e. *Gallinam cum Filiis ſuis*; by the *Arabs* it is called *Dub Aſgher*, i. e. *Urſus Minor*, and *Benat al Naſh al Sughra*, i.e. *Filiæ Feretri Minoris*; by ſome of them it is called *Agiala*, i. e. *Plauſtrum*; by the Perſians it is called *Haphturengh Kihn*, i. e. *Septentrio Minor*; the *Star* in the extremity of the *Tail*, is called by the Arabs *Caucab Shemali*;

*mali*;

*mali*; i. e. *Stella Borealis*; by the Turks, *Yilduz Shemali*; and abſolutely *Yilduz*, i. e, *Stella*; and by a peculiar Name in Arabick it is called *Giedi*, i. e. *Hædus*. The Italians call it *Tramontana*; and we, the *Pole*, or *North Star*. The two laſt and brighteſt in the *Feretrum*, or *Square*, are called by the Arabs *al Phercadan* or *al Pharcadein*, i. e. *Duo Vituli*. The whole *Conſtellation* conſiſting (according to *Ptolomy*) of Eight Stars, whereof one inform. Of the Fabulous *Anaſtroſis* of this and the former *Conſtellation*, *Diadorus Siculus* Reports, that theſe were the *Nurſes* of *Jupiter*, and privately kept him from the ſearch of *Saturn*, for which they were by him, in gratitude placed in the Heavens, and called by the Name of the two *Bears*, being Worſhipped with Divine Rights, by the *Cretians* and *Sicilians*, by whom they were Styled *Deæ Matres*. Others refer it to the Fable of *Caliſto* and her Son *Arcas*; as *Heſiod* and *Ovid*. This *Conſtellation* was firſt diſcovered by *Thales* the *Mileſian*, as *Hyginus* affirms, for which Reaſon it was called likewiſe *Phœnice*, from *Thales* its Inventor, being by deſcent a *Phœnician*, who firſt gave it the Name of *Arctus* or the *Bear*; but trulier ſo denominated from the whole Nation of the *Phœnicians*, who in their Navigations (before *Thales*) obſerved her as their *Directreſs*.

## *DRACO.*

THis *Conſtellation* the Poets feign to have been the *Dragon* that kept the *Heſperides* ſlain by *Hercules*, and made an *Aſteriſm* by *Juno*. Others will have the *Dragon* to be brought by the Giants, in their Flight with the Gods to oppoſe *Minerva*, and by her to have been ſtrangled and thrown up to Heaven, and there fix'd as a Trophy of her Victory. *Schillerus* Attributes this *Aſteriſm* to the *H. Innocents*; but *Schickardus* to *Draco Infernus*.—— It is called by the Greeks Δράκοντος Ἀστερισμὸς, by the Latines *Draco*; in Hebrew *Tannin*, i. e. *Draco*; by the Arabs *Tinnin* and *Tannin*, as the *Hebrew*; it is likewiſe by them likewiſe called *Taaban*, or rather *Thuban*, and in the ſame ſenſe by the Perſians *Aſhdeba*, which is interpreted *Serpens, qui Homines ac Beſtias devorat*. Some among the Arabians give it the Name of *al Haija*, which is alſo appropriate to the Southern *Conſtellation* of the ſame kind. It is made up of 31 Stars; of which, the firſt Star in the Tongue is by the Arabs called *al Rakis*, or *Arrakis*, i. e. *Saltator, ſeu Tripudiator*; the three next *al Awaid*, i. e. *Pulſatores Teſtudinis*. The 5th in the Head is called *Ras al Tinnin*, i. e. *Caput Draconis*. The 14, 15 and 16th are called *al Thâphi*, i. e. *Chytropodes*, from their Poſture, repreſenting a Skillet with Feet, Tripon or Brandiron. The 20 and 21 are called *Adphar al Dib*, i. e. *Ungula Lupi*. The 27 is called *Aldibeh*, i. e. *Victima*, as being placed before that in the Horn of *Capricorn* called *Sa'd al Dahih*, i. e. *Fortuna mactantis*. This *Conſtellation* is ſeen in the Meridian about the end of *June*.

## ENGONASI.

THis *Asterism* in Greek bears the Name of Ἐγγόνασι ϗ Ὀκλάζων, i. e. *Ingeniculus*; and by some of the Latines *Nisus, vel Nixus, quia Laboranti similis*; by the Arabs *Giathi ala Rucbeteihi*, i. e. *Incumbens Genibus.* The Number of Stars in this *Constellation* are by *Ptolomy* reckoned to be 29, of which the first is called *Ras al Giathi*, i. e. *Caput Ingeniculi*, and commonly *Aas al Aben.* That in the *Elbow* from its scituation, is called *Marphak*, that in his *Wrist Mis'am*, i. e. *Carpus*, and commonly *Maasym.*——This *Constellation* some will have to represent *Theseus* or *Ixion*; others *Orpheus* or *Promotheus*; others *Thameris* or *Thamyras* a *Thrasian* Poet; who contending with the *Muses* for Skill, and by them overcome, was punished with the loss of his Eyes; and in the Memorial of their Victory, plac'd in the Heavens in a supplicatory Posture, as deprecating his Punishment: But *Panyases* will have this *Asterism* to represent *Hercules.* This *Constellation* comes to the Meridian at Midnight in the Month of *June.*

## ARCTOPHYLAX or BOOTES.

ARctophylax and *Bootes* are one and the same *Constellation*; the First signifying *Custos Ursorum*, the Latter so called ἀπὸ τȣ̃ Βόος, i. e. *Bovis*, ϗ Ὠθεῖν, i. e. *pellere, quasi Boum Agitator*; but in the Eastern Tongues the same seems to be deriv'd ἀπὸ τȣ̃ Βοᾶν, i. e. *a Clamando*, whence by the Arabs called *al Auwa*, i. e. *Vociferator*, and *al Neckar*, i. e. *Fossor seu Pastinator.*——It consists of 23 Stars.—— This some Fable to be *Lycaon*, others *Arcas*, the Son of *Calisto* his Daughter by *Jupiter*; the Scholiast of *Germanicus* makes it to be the *Constellation* of *Icarus*; and accordingly *Propertius* stiles the *Septentriones, Icarus* his Oxen, in this Verse,

*Flectum Icarii Sidera tarda Boves.*

⁎

Which *Constellation* is seen upon the Meridian at Midnight about the beginning of *May.*

## ARCTURUS.

SOme will have this Star so called, *quasi ab* ὄυρα Ἀρκτȣ̃ i. e. *a Cauda Ursæ*; but trulier, *ad* ὄυρς Ἀρκτȣ̃, i. e. *Custos Ursæ*; in the same sense as *Arctophylax.* This the Arabs call *al Simak al Ramih*, i. e. *Efferens Hasteferim*; in the common Globes and Hemispheres falsly *Huzme.*

## ARIADNES CROWN.

THis by the Greeks is called ςέφανος πρῶτος, i. e. *Corona Borealis, &* *Prima*; and accordingly by the Arabs, *al Iclil Almani*, i. e. *Corona Borealis*, and simply *Al Iclil*, i. e. *Corona*: It is by them likewise called *al Phecca*, i. e. *Apertio*; in Hebrew *Kir Schetali*, i. e. *Corona Sinistra*; and in Chaldee, *Melphelcarti*, i. e. *Sertum Pupillæ.* The Constellation is in Form of a Circle not compleated, and therefore

by the Vulgar Arabs called *Kâse Shekeste*, i. e. *Scutella fracta*: The brightest in this Circle being of the second Magnitude, is called *Lucida Coronæ*, and by the Arabs, *Nair Phecca*, i. e. *Lucida Phecca.* This *Crown*, consisting of Eight Stars, some Fable to have been of Gold: *Athenæus* says it was made of a Flower or Herb called *Theseus*; others will have it to be of *Lawrel* or *Myrtle*; *Bayerus* describes it to have been composed of *Elder Leaves* mixed with *Berries*; *Photius* gives this *Fable* of it: They report (says he) that a certain Nymph Named *Psalacantha* in the Island of *Icaria* being in Love with *Baccus*, endeavoured to procure *Ariadne* to his Bed; on condition he would likewise be kind to her; which *Baccus* refusing, she plotted to do *Ariadne* a mischief: This the God discovering, he in passion Transform'd her to an *Herb* bearing her Name: But afterwards, repenting the Fact, by way of Recompence and Honour, he caus'd the *Flower* to be entwin'd about *Ariadnes Crown*, which he had already fix'd in the Skie. Now most make only *Ariadnes Crown* to be *Constellated*, yet others place *Ariadne* her self in Heaven, as *Scaliger* hath observed; and for proof whereof they add the Testimony of one of *Nero's*, and another of *Trajan's* Silver Coins, having on their Reverse, the Figure of *Ariadne* carried up to Heaven in the same manner as is represented by *Propertius.* *Schillerius* will have it our Saviours Crown of Thorns, but *Harsdersius* will have it to be Queen *Hesters* Crown, *Hest.* 2. 17.

## *ORPHEUS* His *LYRE.*

THis *Constellation* is by *Ptolomy* called λύρας Ἀστέρισμος, and by *Aratus* λύρα κατωφερής, i. e. *Lyra, deorsum pendens*; it is likewise by the Greeks called χέλυς, i. e. *Testudo*; and by the Latines *Lira* and *Fidicula*, and *Vultus cadens*; for it is represented in form of an *Eagle* or *Vultur*, holding a *Lyra* Inverst. By the Arabs it is called *al Lura*, from whence comes the corrupt Name *Alahore* peculiarly Attributed to the first great Star in this *Asterism*: It is likewise called *Sulaphat*, i. e. *Testudo*; the Persians call it *Ciengh Rumi*, i. e. *Cythara Greca*: It consists of 11 Stars; whereof the first is called by the Arabs *Nes'r Waki*, i. e. *Vultur Cadens*: Some Attribute this *Constellation* to the *Lyre* of *Apollo*, others to *Orpheus*, to whom *Mercury*, who first invented it, bequeathed it, and it would refuse to sound at the touch of the Hand of any other Artist. *Schillerus* will have it represent the Manger whereon our Saviour was laid, and *Harsdansius*, *Davids Harp*, 1 *Sam.* 16. 23. It is seen in the Meridian at Midnight in the end of *July*, and partly at the beginning, partly at the End of the Year.

## *OPHIUCUS*, Or *SERPENTARIUS.*

THis *Sign* by the Greeks called Ὀφιοῦχος, and by the Latines *Serpentarius*; is by the Arabs called *al Hawwa*, i. e. one that keeps and Nourishes *Snakes*: It is commonly called *al Hangue*; by the Jews it is called *Ukzerath Hajah*, i. e. *Tenens Serpentem*: It consists of 29 Stars, whereof four inform. The first Star is called *al Rai*, i. e. *Pastor*, and *Ras al Hawwa*, i. e. *Caput Serpentarii*; the second is called *Kelb al Rai*, i. e. *Canis Pastoris*. In this *Constellation* the Ninth Star is more Eminent than the rest, and is called

called *Unuk al Haiya*, i. e. *Collum Serpentis.*——*Æſculapius* is ſaid to have been converted into this Sign for his rare Skill in Phyſick, and particularly for the Cures by him done, by help of an *Herb* ſhewn him by a *Serpent*. *Polizelus Rhodius* Reports, that this *Ophiucus* was *Phorbus* Prince of *Rhodes*, by *Hytilla* the Daughter of *Myrmidon*, who, when that Iſland was extreamly infeſted with *Serpents*, and eſpecially by a great *Dragon*, which devoured many of the Inhabitants, is ſaid to have clear'd the Iſland of the Venemous Beaſts, and to have ſlain the *Dragon*, and in Memorial thereof to have been Conſtellated by *Apollo*. *Kepler* will have this *Conſtellation* to repreſent *Laocoon* the Trojan mentioned by *Virgil*. This *Conſtellation* reaches the *Meridian* at Midnight about the Beginning of *June*; the former part of the *Serpent* about the beginning of *May*; the hinder part about the end of *June*.

## The *S W A N.*

THis *Sign* is called by the Greeks Κύκνος, by *Ptolomy* Ὄρνις, i. e. *Volucris*; by *Ovid Milvius*, and by others of the Latines *Gallina*; according to which laſt it is called by the Arabs *al Dediagie*; to which Anſwers the Hebrew Name *Tharnigoleth*. It is likewiſe by the Arabs called *al Tair*, i. e. *Volucris*, and *Katha*, which is properly an *Aquatick Fowl* reſembling a *Pigeon*. The Perſians call it *Iſpherud*; and the Turks *Baghirtlik*; *Ptolomy* reckons in this *Conſtellation* 19 Stars, whereof two inform. The firſt of which is by the Arabs called *Minkar al Degjagic*, i. e. *Roſtrum Gallinæ*; the 4th *Sadr al Degjagic*, i, e. *Pectus Gallinæ*; the 5th *Danab al Degjagic*, i. e. *Cauda Gallinæ*; and *Hierſym*, i. e. *Roſa, aut Lilium redolens*, as alſo, *al Rid'ph*, i. e. *quæ pone eſt ſeu ſequens*; becauſe it follows four others, whereof two in the Left *Foot*, and two others in the Left *Wing*. The *Fable* of this *Aſteriſm* is, by *Theon*, who makes this *Swan* to be placed in the Heavens not in Memorial of *Jupiter*, but in Honour of *Apollo*, as particularly Dedicated to him, being a Muſical Fowl. It is upon the *Meridian* at Midnight in the Month of *July*.

## The *A R R O W.*

IT is by *Ptolomy* called Οἰςοῦ Ἀστερισμὸς, i. e. *Aſteriſmus Sagittæ ſeu Teli*; in Arabick it is called *al Sah'm*. i. e. *Sagitta*, and in the Globes *al Hance*; in the Hebrew *Chetz*: *Kircher* ſays it is in Hebrew Named *Satan ſeu Demon*; and that the Turks call it *Orfercalem*: It conſiſts of 5 Stars. This was the *Arrow*, with which *Hercules* ſlew the *Vulture* that Fed upon *Promethius* his Liver: And *Promethius* being received into favour with *Jupiter*, the *Arrow* in Memorial was made an *Aſteriſm* in Heaven; by *Cicero* called *Muſator*, by others *Temo Meridianus*: It Tranſperſes one of the *Wings* of the *Eagle*; and paſſes the Meridian at Midnight about the Middle of *July*.

## The *E A G L E.*

IN the Greek this *Conſtellation* is called Διός Ὄρνις, i. e. *Aquila*, & *Jovis Ales*; it is likewiſe called in Arabick *Okab*, i. e. *Aquila Nigra*; by *Geſner* called *Leporaria*, which in the Perſian Tongue is called *Alnk*; in Turkiſh, *Tauſhangjil*, i. e. *Aquila Leporaria*; in Hebrew it is called

*Neſcher*

*Nescher*, which signifies an *Eagle*: It consists of 9 Stars, of which the third is called by the Arabs *al Nes'r al Tair*, i. e. *Vultur volens*; it is also called *Lucida Aquila*; the 9th Star is called *Danab Alakab*, i. e. *Cauda Aquilæ*.——This *Eagle* (according to the Poets) was Constellated by *Jupiter* for the Rape of *Ganymed*; or (according to *Agloasthenes*) for that *Jupiter* going from *Naxus*, to War against the *Titans*, an *Eagle*, as he was Sacrificing, appeared to him in a happy Auspice; whereupon, after his *Victory*, he took that *Fowl* into his particular Patronage. But *Mero* gives us the *Fable* quite otherwise; for he Writes that the *Eagle* was *Constellated* by *Jupiter*, for suckling him when an Infant in *Creet*, with *Nectar*, which she first Drank from a Rock, and then brought it to the God. About the middle of *July*, at Midnight it may be seen on the Meridian.

## The DOLPHIN.

BY the Greek it is called Δελφῖνος Ἀστερισμὸς, i. e. *Asterismus Delphinis*; by others ἱερὸς ἰχθὺς, i. e. *Pisces Sacer*; in Hebrew *Dagaim*, i. e. *Pisces Maris*; the Arabs call it *Dulphin*; in which the most Eminent Star is one in the Tail, called by the Arabs *Danab al Dulphin*, i. e. *Cauda Delphinis*. This *Asterism* is by *Cicero* called *Currus*; and by *Pliny Hermippus*; and by some others *Rhomboides*. This *Constellation* is famous for the Number of Stars in it being equal to the Number of the *Muses*; and also Famous; *Quod fuit Occultis fælix in amoribus Index*; as being Instrumental to *Neptune* in his Amorous pursuit of *Amphitrite*, who fled, and conceal'd her self from him: Nor is this *Asterism* less Signal for the Fabulous Transport of *Arian*, in *Ovid. Fast. l.* 2. It passes towards the Meridian at Midnight about the end of *July*.

## PEGASUS.

THis *Constellation* is called *Pegasus*; by the Greeks, Ἡμιτελὴς ἵππος, It is called likewise *Equus Major, Medusæus, Gorgonias, Bellerophontæus* and *Menalippe*; by the Arabs *al Pharas Adam*, i e. *Equus Major*, and *Alpharas al Thani*, i. e. *Equus Secundus*; in Hebrew it is call'd *Hasus chail Kernim*, i. e. *Equus Cornutus*: It consists of 20 Stars; amongst which the chief, by the Arabs called *Sirræ al Pharas*, i. e. *Umbilicus Equi*: That in the joyning of the Wing is called *Marchab*, i. e. *Equitandi vel vehendi Locus, Sagma, Ephippium*. Some Fable this to be *Bellerophons*, others *Perseus* his Horse: *Callimachus* and *Catullus* call him *Unigeniam Memnonis*, Brother to *Memnon* and Son of *Aurora*: The Greek Commentators make him to have been presented to *Aurora* by *Jupiter*: But *Lycophron* describes him to be the *Winged Steed* of the *Morning*, upon which she is said to *Ride*. *Palapharus* and *Artemidorus* make *Pegasus* to be a *Ship* and not a *Horse*: And according to *Vassus*, the Name *Pegasus* seems to be derived a πήγω i. e. *compingo, quia Navis e multis componitur lignis*. It is seen in the *Meridian* at Midnight about the middle of *August*, and beginning of *September*.

ANDRO-

## ANDROMEDA.

THis *Asterism* is called by the Arabs *al Mara al Mosalsala*, i. e. *Mulier Catenata*; In Hebrew *Isha Shalahajala Baal*, i. e. *Fœmina carens viro*. It consists of 27 Stars; among which the 12th called by the Arabs *Giemb al Mosalsala*, i. e. *Latus Catenatæ*; that in her *Girdle* is called *Izar* and *Mizar*; that in the Border of her *Vest* they call *al Deil*, *vel Addeil*, i. e. *Syrma seu Lacinia Vestis*; the 15th is called *Rigil al Mosalsala*, i. e. *Pes Catenatæ*. This Constellation comes to the Meridian about the middle of *October*. As to the Fable of *Andromeda*, see after in the Whale.

## PERSEUS.

THis *Constellation* is by the Arabs called *Cheleub* or *Chelub*, i. e. *Deceptor*; and from the Greek Name *Perseus*, *Bershaush* and *Bersheush*; it is likewise called by them *Himel Ras al Ghul*, i. e. *Portans caput Larvæ*: It consists of 29 Stars, of which 3 inform. The first is called *Misam al Thuraiya*, i. e. *Carpus Pleiadum*, and *al Giemb Bershaush*, i. e. *Latus Persei*; the 12th is called *Ras al Ghul*, i. e. *Caput Larvæ*; by the Jews, *Rosh ha Sathan*, i. e. *Caput Diaboli*, the 24th called *Menkib al Thuraiya*, i. e. *Interscapillium Pleiadum*. This *Perstus* was the Grand Child of *Acrisius* King of the *Argives* begotten by *Jupiter* on his Daughter *Danae*, placed in Heaven by favour of *Minerva*, for having slain *Medusa* or the *Gorgon*, and freed *Andromeda* from the devouring Sea Monster. This *Asterism* is on the Meridian at Midnight in the Month of *November*.

## DELTOTON.

CAlled also *Trigones* and *Delta*; by the Latines *Triangulum*, and *Nili Donum*; by the Arabs; *Mothallath*, i. e. *Triangulum*; in Hebrew, *Himmosclush*, i. e. *Tripartius*. It consists of four Stars, that in the top of the Triangle is called in Arabick, *Ras Almothallath*, i. e. *Caput Trianguli*. This Constellation is said to have been placed in Heaven by *Mercury*, in Memorial of the first Letter of *Jupiters* Name, Διὸς, *Bassus* in *Germanicum*, and *Hyginus* Write, that *Mercury* at the Command of *Jupiter*, placed it over the Head of *Aries*, as a Mark the better to discern that Sign of it self.

—— *Obscuro lumine labens.*

As *Cicero* in *Aratæis*. Others will have it to be the Figure of that part of *Ægypt* Constellated, which *Nilus* after that manner encompasses. This Asterism at Midnight comes to the Meridian in *October*.

CEPHEUS.

## CEPHEUS.

THE true Name of this Aſteriſm by the Arabs is *Keiphus*; In Hebrew it is called *Baalath Hala*, i. e. *Domina Flammæ*; and in Arabick *Multahab*, i. e. *Inflammatus*. This Conſtellation conſiſts of 13 Stars, whereof two inform: Among which there is one in the Foot called *Al Rai*, i. e. *Paſtor*; and between his Feet another called *Al Kelb*, i. e. *Canis*; and upon his Hands certain others called *Al Agh'nâm*, i. e. *Pecudes*. The 3d, 4th and 5th, are by *Ulugh Beigh* called *Cawakib al Phirk*, i. e. *Stella Gregis*.——This *Cepheus* was Son of *Belus*, by *Anchinoe* the Daughter of *Nilus*, from whence the Perſians were heretofore called Κηφῆνες, over whom he was King, as likewiſe of *Phœnicia*, and Reigned both in *Babylon* and *Joppa*; reckoned among the Royal Fautors of Aſtronomy. It is beheld in the Meridian at Midnight about the end of *Auguſt*, and beginning of *September*.

## CASSIOPEA.

IT is likewiſe called by the Greeks γυνὴ τοῦ θρόνου, i. e. *Mulier ſedis, ſive Throni*; by the Arabs *Dât al Curſa*, i. e. *Inthronata*. It is alſo known by the Latin Name of *Cathedra*, *Thronus & ſedes Regia*; it conſiſts of 13 Stars according to *Ptolomy*, but *Tycho* hath obſerved therein no leſs than 45, beſides the *New Star* which appear'd in the Year 1573, and vaniſhed the Year following: It is reſembled by *Aratus* to the form of a *Laconian* or a *Carian* Key.——The firſt Star in this Conſtellation is by the Arabs called *Caph al Chadib*, i. e. *Manus tincta*. The ſecond Star is called by the Name of the whole Conſtellation, *Dât al Curſa*. The fifth is called *Rucba Dât al Curſa*, i. e. *Genu Inthronatæ*. The bright one in the Breaſt is called *Sad'r*, i. e. *Pectus*. This *Caſſiopea* was the Wife of *Cepheus*, and Mother of *Andromeda*, who contending for Beauty with the *Nereides*, was, as a Puniſhment, and in Memorial of her Arrogance, placed in Heaven with her Heels upwards. But *Tycho* gives us a better ground of the Fable, who writes, That *Cepheus* was a great Aſtronomer, or, at leaſt, a Favourer of the Profeſſors of that Science, who in a grateful acknowledgment of his Encouragement of their Studies, gave to ſeveral Conſtellations the Name of his *Wife*, *Daughter*, and *Son-in-Law*, which he received from *Cicero*. He likewiſe reports, That in the time of *Cepheus*, thoſe Stars which make the Conſtellation of *Caſſiopea* did riſe with the firſt degree of *Aries*; and that under that Conſtellation the *Æthiopeans* did ſolemnize the Inauguration of their ſucceeding Kings, in Memorial of their firſt Mother *Caſſiopea*, whom he ſuppoſes more probably to have been called *Caſſiepea*. This Aſteriſm is diſcovered in the Meridian, partly in the end of *March* and beginning of *May*; partly at the end of *September* and beginning of *October*.

## CAPUT ALGOL: OR, MEDUSA's HEAD.

THE Fable concerning this Conſtellation is this. *Perſeus* coming into Mans Eſtate, and being furniſhed with Sword, Hat and Wings, of his Brother *Mercury*, was ſent by his Foſter Father *Polydectes* to kill the Monſter *Meduſa*, who was to have devoured *Andromeda*, who for the Pride of her Mother *Caſſiopea*, was bound with a Chain to a Rock by the Sea ſide for that purpoſe; but *Perſeus* pitying her caſe, undertook to fight with the Monſter upon condition that *Andromeda* might be his Wife: Whereupon he ſlew the Monſter, and Delivered and Married *Andromeda*, and returned home to the Iſle of *Seriphus* with the *Gorgons* Head. For which Exploit, *Jupiter* his Father took him up into Heaven, and there placed him in the form he overcame *Meduſa*, with his Sword in one Hand, the Head of *Meduſa* in the other, and the Wings of *Mercury* at his Heels. *Schillerius* attributes it to St. *Paul*; *Shickardus* to *David* with the Head of *Goliah*.

## HENIOCHUS.

THis by the Greeks is called Ἱππολατης, Ἑλάσιππος, Ἁρμηλάτης, καὶ Διφρηλάτης; by the Jews *Ha Roah ſcobido Hareſan*, i. e. *Paſtor tenens frénum*; and in the ſame ſenſe by the Arabs, Maſik *al Inan*, i. e. *Tenens Habenam*, or Mumſik *al Amna*, i. e. *Tenens Habenas*, to which the Greek Name *Heuiochus* anſwers, *i. e. Habenifer.*——It conſiſts of 14 Stars, among which the 4th is called *Menkib Dil Inan*, i. e. *Humerus Heniochi*: The 11th *Ca'b Dil Inan*, i. e. *Talus Henioce.*——This Conſtellation the Scholiaſts of *Germanicus* will have to be *Mirtillus*: The *Trezenians* are for *Hippolitus*; others for *Ericthonius*, who *Pliny* makes the firſt that join'd Four Horſes in a Chariot. *Euſebius* makes *Trochilus* the *Argive*, who was the Son of *Callithea* the Prieſteſs of *Juno*, the firſt Inventer thereof: Others will have him to be *Oenomaus*. This Sign attains the Meridian at Midnight about the middle of *December*.

## HÆDI, or the KIDS.

THeſe are two Stars in the Left Arm of *Heniochus*, called by the Arabs *Sadateni*, i. e. *Brachium ſequentes*. They are likewiſe called *Giedyân*, and *Maazein*, i. e. *Duo Capri*. Theſe *Cleoſtratus* the *Tenedian* is ſaid firſt to have diſcovered: They are ſaid both at their Riſing

Riſing and Setting to cauſe Storms and Tempeſts, and therefore by the Poets called *Horrida & inſana Sydera.*

## The AMATHÆAN GOAT.

THis is a bright Star in the Shoulder of *Heniochus*, of the firſt Magnitude, called by the Arabs *Aiyuk*, and commonly, inſtead thereof, *Atud.* In Hebrew, *Aſh* or *Aiſh*; in Syriack *Jyutho*; all ſignifying *Capellum.* This the Poets Fable to have been the Mother of the two *Kids*, and Nurſe to *Jupiter*; tho others report him to have been Suckled by a *Sow*; the *Cretans*, for that cauſe, honouring that Creature as Sacred. But the more General Opinion is, That he was Suckled by a Goat, and from thence he deriv'd the Title of *Ægiochus*, or the *Goat-Nurſt.* And to this effect, in ſome Medals of the Emperor *Valerianus*, he is repreſented in the Figure of a Child mounted on the back of a Goat, with this Inſcription, JOVI CRESCENTI. I ſhall hereunto only apply an Ingenious Epigram of *Crinagoras*, in Greek, upon a Goat, whoſe Milk *Auguſtus Cæſar* uſed to Drink.

Thus *Engliſhed:*

*When* Cæſar *did our full Bags Nectar taſte,*
*Whoſe Spring th'Exhauſting Pole could never waſte;*
*Me, that he might not want that Milkey ſtore,*
*To Sea, with him, in his own Ship he bore.*
*Streight 'mong the Stars, ſhall I be made to ſhine,*
*For he I ſerve, than* Jove's, *no leſs Divine.*

## PLEIADES and HYADES.

SEven Stars on the back of the *Bull*, by the Latines, from the time of their Riſing, called *Vergiliæ*; by the Greeks ἀπὸ τοῦ πλεῖν; by the Arabs *Al Thuraiya*, i. e. *Multus ſeu Copioſus.* They are likewiſe by them called *Al Negim*, i. e. *Aſtrum*; by the Syrians they are called *Chimo*; by the Perſians *Peru*, and *Peruin*; by the Turks *Ulger*; by the Jews *Chima*, and *Succoth Benoth.* Theſe are ſaid to have been the Daughters of *Atlas* and *Pleione*, whom *Mero* makes the Nurſe of *Jupiter*, who fed him with *Ambroſia*; but commonly they are reputed the Nurſes of *Baccus*, and for that Conſtellated. Their Names are *Maia*, *Sterope*, *Taygeta*, *Celæno*, *Electra*, *Merope*; or, according to the Scholiaſt of *Theocr. Coacymo*, *Glaucia*, *Protis*, *Parthenia*, *Maia*, *Stonychia*, *Lampado.* *Michael Florentius* adds to them two other Stars, which he calls *Atlas* and *Pleione.* *Galileus* hath obſerved in this Conſtellation above 40 Stars; and *Ricciolus* no leſs than 40.

The ſeven Stars in the Head of the *Bull*, called by the Greeks *Pleiades*, the Latines call *Succulæ*, from the Greek Letter υ *Upſilon*, which they reſemble, or from their Mother *Hya*, Daughter of *Oceanus*, and Wife of *Atlas*; by *Ulugh Beigh* they are called *Al Debarân*,

 however

however that Name is peculiarly applied to the brighteſt of them, commonly called *Oculus Tauri*; in Hebrew they are called *Chima*, from the number of Stars of which they conſiſt. Theſe exceſſively lamenting the Death of their Brother *Hyas*, who in Hunting was ſlain by a Lion, were, by the commiſerating Gods, converted into Stars, whoſe Names are *Ambroſia*, *Eudora* (or *Eudoxa*) *Pheſile*, (or *Paſithea*) *Phileto*, (or *Pytho*) *Thyene*, (or *Tuke*) *Coronis* and *Prolixo* (or *Plexauris*.)

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## III. Of the Ancient Southern Constellations.

### *ORION.*

THis Conſtellation was firſt by the *Bœtians* called *Candaon*, afterwards Ὠάειον, called by the Latines *Hyriades* and *Hyrides*, from his Father *Hyries*. It is by *Plautus*, *Feſtus* and *Varro*, called *Jugula*, *eo quod armatus ſit ut Gladius*; by the Jews it is called *Gibbor*, i. e. *Gigas*, and *Kelb Ha Giebbor*, i. e. *Canis fortis*, and *Bellator Fortis*; by the Arabs *Al Gianza*, and alſo *Al Giebbar*, i. e. *Gigas fortis*; in Syriack it is called *Gavoro*; in Caldie *Niphla*. It conſiſts of 38 Stars, amongſt which the firſt is called *Hecka*, i. e. *a white Circle*; by which Name the 3 Stars in the Head are denominated. The ſecond is called *Menkigh al Gianza*, i. e. *Humerus Orionis*; and *Jed al Gianza al Jumma*, i. e. *Manus dextra Orionis*. The 3d is called *Mirzam al Nagiid*, i. e. *Leo Strenuus*. The 17th and 25th are in the Arabick called *Al Tagis*, and *Al Dawâib*, the firſt ſignifying *Tiara*, the other *Antiæ ſeu Lemniſci*. The 26th, 27th and 28th, are called *Mintaka al Gianza*, and *Nitak al Gianza*, i. e. *Cingulum ſeu Baltheus Orionis*. The 29th, 30th, 31 and 32, are called *Saiph al Giebbar*, i. e. *Enſis Gigantis*. The 35th is called *Rigil al Gianza al Juſra*, i. e. *Pes Gigantis Siniſter*; and *Rai al Gianza*, i. e. *Paſtor Orionis*. The 38th is called *Rigil al Jumma*, i. e. *Pes Dexter*.—The Fable of this Conſtellation is by ſome thus related: *Orion* being a great Companion of *Diana*'s in her Hunting Diverſions, *Apollo* grew Jealous of his too much familiarity with his Siſter, and to be Revenged, ſeeing *Orion* one day ſwimming in the Sea, his Head appearing above the Water like a black Mark, he ſhew'd it to his Siſter, and told her ſhe could not hit it; whereupon, ſhe preſently drawing her Bow, let fly, and kill'd him, not knowing who he was, till the Sea had caſt him on the Shore; which perceiving, and much troubled, to make amends, ſhe plac'd him in Heaven near the *Dog* and the *Hare*, where he ſeems ſtill to Hunt. The Perſians will have this Aſteriſm to repreſent *Nimrod*. It is ſeen in the Meridian at Midnight in the Month of *December*.

## SIRIUS, or the GREAT DOG.

THis is Fabled to be *Orion*'s Dog, Named *Lælaps*; others make it *Isis* her Dog: Some again make it *Cephalus*'s. By *Ovid* it is called *Canis Icarius* and *Erigonus*. By the Greeks Κυνος Ἀστεισμὸς, i. e. *Canis Asterismus*. By the Latines it is called *Canicula*; the Ancient Ægyptians believed this Constellation to be the Soul of *Isis*. *Germanicus* and *Hyginus* give it the Name of *Mæra*; the Æthiopians give it to *Nilus*, as if it were *Sydus Niloticum*, by reason of the great affinity between *Nilus* and that Star, for in the Dog-Days, that River hath its greatest Inundation. By the Arabs it is called *Kelb Acbur*, i. e. *Canis Major*; by the Syrians *Kelbo Gavoro*, i. e. *Canis Gigantis*; by the Ægyptians it was called *Sothis*, in Memory of a King of that Name, Father to *Rhameses*, who was a great Erecter of Obelisks, and Restorer of the Ægyptian Learning. This Constellation contains 29 Stars, whereof 11 inform: It is seen in the Meridian at Midnight about the end of *December*.

## LEPUS the HARE.

THis Constellation is by the Greeks called λαγωος, ἢ λέποϱις; by the Latines *Lepus*. The Arabs call it *Arneb*; and the Jews *Arnebeth*, i. e. *Lepus*. It consists of 12 Stars, whereof the 7th, 8th, 9th and 10th, are called in Arabick *Arsh al Gianza*, i. e. *Solium Orionis*. Some will have this placed in Heaven in Memorial of the Chase affected by *Diana* and *Orion*; Others make *Mercury* the Author of this Constellation, in Testimony of the fruitfulness and pregnancy of this Creature. *Hyginus* and *Bassur* write, That Anciently in the Island *Hiero* there was no Hares, until one of the Islanders brought thither from beyond the Seas a Female big with Young; and that from thence, in a short time, they increased, and grew so numerous, as wanting sufficient Food, they destroy'd all the Crop in the Island, and brought a Famine upon the Place. In Memorial of which, this Asterism was Figured in the Heavens.—To this purpose there is an Ingenious Epigram of *Cæsar Germanicus* in Greek.

Thus *Englished*.

*A* Hare *by* Hounds *pursu'd, them having scap'd*
*Met on the shore a* Dog-fish, *and was snap'd:*
*Then cries, Us* Earth *and* Seas *are bent t'undo,*
*Heaven's only left*; *yet there is a* Dog *too.*

This Constellation is seen in the Meridian at Midnight in the Month of *December*.

PROCYON,

## PROCTON, or the LITTLE DOG.

CAlled likewise *Canis Minor*; *Procynis* and *Præcanis*; but *Cicero* and *Ausonius*, *Anticanis*. *Pliny* says that the Romans had no Name for it, unless *Caniculam*. By the Arabs it is called *Kelb Asgher*, i. e. *Canis Minor*; it is likewise by them called *Shirâ al Shamija*, i. e. *Syrius Shamensis*. The Arabs make the greater and lesser *Dogs* to be the Sisters of *Canopus*; but the Poets Fable this *Little Dog* to have been *Erigone*'s Dog, who mourned to Death for the loss of his Mistriss, who Hanged her self for Grief that her Father *Icorus* was slain by his Drunken Peasants. This Constellation consists only of two Stars, as *Ptolomy*, of which, that in his Shoulder is by the Arabs called *Al Mirzam*, and *Al Dira al Mesbuta*, i. e. *Brachium expansum*; the other at the Root of the Tail they call *Al Shira*, *Al Shamiya*, i. e. *Syrius Shamensis*, and *Al Ghomeisa*. It is seen in the Meridian in the Month of *January* at Midnight.

## ARGO, NAVIS.

THis Constellation is by *Ptolomy* called Ἀργοῦς Ἀστερισμὸς, and by some simply Ναῦς, i. e. *Navis*; by the Arabs *Mercab*, i. e. *Currus seu vehiculum*; for so, by the Poets, the Ship *Argo*, which this Asterism represents, is called *Currus volitans*. It is likewise in Arabick called *Al Sephina*, i. e. *Navis*. It consists, according to *Ptolomy*, of 45 Stars; by *Sayerus* of 63; and by *Kepler* of 53. There are several Stars of second Magnitude not far from it, which by the Arabs are called *Soheil Telkin vel Belkin*; or (as Mr. *Hide* reads it) *Belkis*, that being the Name of the Queen of *Sheba* that came to visit *Solomon*. The Poets feign this to be the Ship wherein *Jason* did fetch the *Golden Fleece* from *Colchis*; some will have it to be the *Ark of Noah*. *Navidius* saith it is the Ship wherein the Apostles were when Christ appeared unto them walking on the Sea. The Poets do generally agree that this Ship was the first that ever Sail'd the Seas, but *Diodorus Siculus* plainly affirms the contrary, for speaking of *Jason*, he says that he first, under the Mountain *Pelius*, built a Ship of far greater bulk than any that were then us'd, for at that time Men only Sail'd in small Barks or Skiffs; so that this *Argo* seems not to be the first Ship, but rather the first of its kind. This Ship arrives to the Meridian at Midnight about the end of *January*.

## DRACO.

THis Serpent is by *Ptolomy* called Ὕδρυ Ἀστερισμός, i. e. *Hydri Asterismus*; by the Greeks it is called Ἀσβία, and by the Arabs *Alshugia*, i. e. *Serpens tenuis*. *Ricciolus* says it is in Arabick called *El Hawick*; and *Kepler*, *Aphaak*; in Hebrew *Hajah*, i.e. *Serpens*. In this Constellation there are 32 Stars, 7 inform, whereof the first Star is called *Minchir al Shugjâ*, and the others, from that to the seventh, inclusive, *Min al A'zal*, i. e. *Ex Inermi*, as if appertaining to the Sign *Virgo*. The 12th Star called by the Latines *Cor Hydræ*, is in the Persian Tables called Ὕδρυ Ἀυχὴν, and accordingly in *Ulugh Beigh*, *Unuk al Shugja*, *Collum Serpentis*; and *Pherd al Shugja*, i. e. *Solitaria Hydri*. The Head of this Constellation is seen in the Meridian at Midnight about the beginning of *February*; its Middle about Mid-*March*; and its Tail in the beginning of *April*.

## CORVUS the CROW.

THis by the Greeks is called Κόραξ καὶ Κόρακος, i. e. *Corvus*, & *Corvi Asterismus*; by the Jews it is called *Oreu*, and from thence by the Arabs *Al Gorab*, *Corvus*. It is likewise by them called *Al Chiba*, i. e. *Tentorium*; and *Arsh al Simak*, i. e. *Solium efferentis* (*scil. intermem vel Verginem*) and *Agiar al Asad*, i. e. *Clunes Leonis*; and *Al Agimal*, i. e. *Cameli*: It is seated upon the Tail of the Serpent, and consists of 7 Stars, of which the first is called in Arabick *Minkar al Gorab*, i. e. *Rostrum Corvi*; the fourth *Gienah al Goras al Siman*, i. e. *Ala dextra Corvi*. The Fable of this Constellation is thus: The Crow being sent by *Apollo* to fetch Water for a Libation, seeing a Fig-Tree full of Figs, but not Ripe, made stay there until the Figs were come to maturity (which Fable seems to be derived, says *Bochart*, from *Noah*'s sending the Crow out of the Ark) and having satisfy'd his longing, went to the Fountain to fetch Water, but coming thither meets with the Serpent before-mentioned, whereat affrighted, he returns back with the empty Pitcher, telling *Apollo* there was no Water in the Fountain. This untruth being discovered by *Apollo*, he Prohibited the Crow for ever Drinking at that time of the Year, and in Memorial of the Fact, plac'd the Crow, Snake and Pitcher, in the Heavens. The Crow is Sacred to *Apollo*, the President of Divination; forasmuch as this Fowl, by its different Notes, is said to foretel Fair and Foul Weather; or for that *Apollo*, fearing the pursuit of *Typhon*, is said to have assum'd the Figure of that Fowl; or in allusion to the Suns departure, causing darkness and Night of the same Colour with the Crow, as his return does the Day or Light, resembling the whiteness of the Swan, which is likewise Sacred to that God. This Asterism is seen in the Meridian at Midnight about the middle of *March*.

The

## The *CUP.*

MAuilius appropriates this Cup to *Bacchus*; *Aratus Hyginus*, and *Bassus*, to *Apollo*, according to the foregoing Fable. It is called by *Ptolomy* Κρατὴρ Ἀστερισμὸς; by others, *Hydria, Calpe, Cratera, Patera, Urna & Vas*; by the Arabs, *Batyra*, i. e. *Poculum Magnum*; by some it is called *Alkis*, i. e. *Cyathus*, from the Hebrew *Kus* or *Kos*, signifying the same. It consists according to *Kepler* of Eight Stars, which by the Arabs are called *al Ma'laph*, i. e. *Præsepe*: It is apparent in the Meridian at Midnight; about the middle of *March*.

## *CENTAURE.*

SOme will have this to be *Minotaur*; others *Chyron*, the Son of *Saturn*; and *Phillyra* the Daughter of *Oceanus*, who taught *Æsculapius* Physick; *Achilles* Musick, and *Hercules* Astronomy; with one of whose Poysonous Arrows, casually falling out of his Quiver, he was Wounded in the Foot; and of that Wound died, and by commiserating *Jupiter* was made a Sign in Heaven; called by *Ptolomy* Κένταυρος Ἀστερισμὸς. The Arabs making use of the Greek Name, by whom yet, according to *Ricciolus* it is called *Albeze*, and *Asmeat*; by the Greeks Φὴρ; and in Barbarous Greek *Taraopoz*: It consists, as *Ptolomy*, of 37 Stars; all which, together with those that make up the *Fera Centauri*, are by the Arabs called promiscuously *Alshamarich*, i.e. *Spadices*, bright dappled: The 35 Star is, by *Vulugh Beigh*, called *Rigil Kentaurus*, i. e. *Pes Centauri*. This Constellation passes the Meridian at Midnight at the end of *April*.

## The *ALTAR.*

CAlled by the Greeks θυμιατήριον, πυράμμη κὴ Φάρος, by the Latines *Thuribulum, Conceptaculum, Bathilius, Sacrarium, Puteus, Templum, Lar, Acerra, Ara, & Altare*; by the Arabs, *Almegramet* or *al Mugramrah*. It consists of 7 Stars, This was the first Altar (according to the Poets) that was ever Erected: It was Fram'd by the *Cyclops*, and in Memorial of the Fact Constellated. *Lactantius* Reports, that the first Altar that *Jupiter* Erected, was in Honour to *Cœlus*: But the Deities to whom *Jupiter* Sacrificed upon this Expedition against the Giants, we find (from *Diodorus Siculus*) to have been the Sun, Heaven, and the Earth. This *Constellation* comes to the Meridian at Midnight about the End of *June*.

## The *WHALE.*

THis Asterism is by the Greeks called Κῆτος, πίστις ϰ̀ Ορφος, by the Latines, *Cete* and *Cetus, Balena; Pistrix, Leo*, or *Ursus Marinus*: By the Arabs *Alketus*: *Ptolomy* reckons in it 22 Stars; and *Kepler* 25; of which, the Bright one in the Snout of the *Whale* is called *Menkar Alketus*, i. e. *Rostrum Ceti*: That in the Tail, *Danab Alketus*, i. e. *Cauda Ceti*; and both these by the Arabs are called *al Diphdaan*, i. e. *duæ Ranæ*: There are two also in the Hands (for this Fish is conceived to be the same with *Dagon*, or *Derceto* the *Syrian* Idol, which was represented in the Upper part after a humane shape, in the lower, after that of a Fish; and by the Jews Named *Adir Dag*, i. e. *Piscis Magnus*: They are by the Arabs called *al Naaman* or *al Naamat*, i. e. *Struthio Cameli*: The second Star in this Constellation is called *Caph al Giedma*, i. e. *Manus Truncata*: The 21 Star is called *Danab al Ketus Shemali*, i. e. *Ceti Cauda Borealis*: The 22th *Danab al Gienubi*, i. e. *Cauda Australis*; and *al Diphda al Tha'ni*, i. e. *Rana Secunda*: This Constellation is seen in the Meridian at Midnight, from the beginning of *October* to the end of *December*.

## The Southern *FISH.*

THE Poets Fable this to have been the Fish which saved *Phacetis*, or *Aphacitis*, the Daughter of *Venus* fallen into the Lake *Boeth*; and for that Reason Constellated; by the Arabs called *al Haut, al Gienubi*, i. e. *Piscis Australis*: *Hyginus* calls it, *Piscis Solitarius*; and *Bassus*, *Piscis Magnus*: And it is said to have Spawned the other two in the Zodiack: It consists of 12 Stars, amongst which the Bright one in the Mouth is called *al Diphda al Auwal*, i. e. *Rana Prima*, and *al Dalim*, i. e. *Agger*; and *Phom al Hont*, i. e. *Os Phiscis*; and commonly (but erroneously) *Phomahant*: It is seen in the Meridian at Midnight about the middle of *August*.

## *ERIDANUS*, or *PADUS.*

IT is a Southern Asterism, which some will have to be made a Constellation in Memory of *Phaeton*, who was Drowned therein; the *Egyptians* Challenge it for their *Nilus*. It is called by the Greeks ποταμὸς Ωρίωνος, i. e. *Fluvius Orionis*, because it springs from the Left Foot of *Orion*, and runs from thence in a fluxious Course Southward: It is likewise called *Gyhon*, and *Vardi*, i. e. *Fluvius*; by the Moors *Guad*; and by the Arabs *Nah'r*: The *Thuscans* call it *Botignon*; the *Ligurians*, *Botigum*. It consists of 34 Stars, of which that of the first Magnitude is by the Arabs called *al Dalim*, i. e. *Agger*; it is likewise called in Arabick *Acher Nah'r*. i. e. *Ultima Fluminis*; whence the common Name *Acarnar*: It is seen upon the Meridian at Midnight in *November*.

### *CORONA AUSTRALIS* ſive *NOTIA.*

IT is called by the Greek Poets Ἰξίονος τρόχος, i. e. *Rota Ixionis* : The Arabs give it different Names, as *al Cubba*, i. e. *Teſtitudo vel Tabernaculum*; and *Az'ha al Naam*, i. e. *Nidus Struthionis*. This Conſtellation conſiſts of 13 Stars. It is Fabled to be made a Conſtellation by *Bacchus*, in Honour and Remembrance of his Mother *Semele*. It comes to the Meridian at Midnight (but not viſible in our Horizon) in the beginning of *July*.

## IV. *Of ſuch other Conſtellations Northern and Southern; as have been Diſcovered by Modern* ASTRONOMERS.

### I. Modern Northern CONSTELLATIONS.

### *COMA BERENICES.*

IT is by *Bayerus* called πλόκαμος, i. e. *Coma, Spicarum Manipulus* : The Arabs call it *Alhand*, i. e. *Lacus ſeu Ciſterna* : It conſiſts of 7 Stars. The Original of this Conſtellation was from *Berenice* , the Wife of *Ptolemæus Energetes*, who Vowed, if her Husband returned Victorious from his *Aſian* Expedition, ſhe would ſhave her Head and Offer her Hair to *Venus* to be hung up in her Temple; which being accordingly performed; it was, the next day after the Offering thereof, found miſſing; whereupon *Conon*, to flatter King *Ptolomy*, diſcovered to him, that the Head of Hair was Tranſlated to Heaven, and made a Celeſtial Conſtellation.

### *ANTINOUS* and *GANIMED.*

THeſe are one and the ſame Conſtellation; for the Aſteriſm which by the Greeks is feigned to repreſent *Ganymed* Rap'd by the *Eagle*, and carried up to Heaven to ſerve *Jupiter* as a Cup-Bearer; the Romans in Honour to *Antinous* (the beloved Favorite of *Hadrian* the Emperour) will have to be the Repreſentation of that Beautiful *Bythinian*, who dying a Voluntary Death for the Welfare of the Emperor, was by him Honoured with Statues, Temples, Prieſts, and a place among the Celeſtial Conſtellations; between the *Eagle* and *Sagittarius*. It conſiſts of 7 Stars; and comes to the Meridian about the middle of *July*.

## EQUULEUS.

THis Aſteriſm, called alſo the Leſſer Horſe; is by *Ptolemy* called ἵππου προτομῆς, Ἀστερισμὸς by others τομὴ τοῦ ἵππου, i. e. *Sectio Equi*: In *Chryſococca's* Tables Κεφαλὴ ἵππου, i. e. *Caput Equi*; by *Ulugh Beigh*, *Kit'a al Pharas*, i. e. *Sectio, Præciſſio, vel, Segmentum Equi*; but by others of the Arabs called *al Pharas al Anwal*, i. e. *Equus Primus*; it conſiſts of four Stars in form of a Horſes Head and Neck: It comes to the Meridian at Midnight at the beginning of *Auguſt*.

¶ To theſe Northern Conſtellations ſome late Aſtronomers have added ſeveral other *Aſteriſms*, compoſed out of the Inform Stars: As of thoſe between the *Greater Bear* and the Sign *Leo*; they have formed the River *Jordan*——Of thoſe between the North-Pole, *Perſius* and *Auriga*, an Aſteriſm called *Camelo Pardalis* and *Gyraffa*.——Of the four Stars interpoſed between the Triangle and Tail of the *Ram*, another called *Veſpa*; by ſome *Apes*; i, e. the *Waſp* or the *Bees*——Of the Tract of Stars Running between the *Swan* and the *Eagle*, as far as *Serpentarius*, they have formed the River *Tigris* or *Euphrates*——And to a ſingle Star of the ſecond Magnitude, placed in the middle between *Charles his Wain* and *Coma Berenices* (from which if a Right Line be drawn through the firſt Star in the Tail of *Urſa Major*, towards the Pole, it will point directly to the *Pole Star*) they have given in Memory of the moſt Glorious Prince and Martyr *CHARLES* the I. King of *England*, the Name of *Cor Caroli*. The Primary Invention and Denomination thereof being owing to the moſt Loyal and Learned Sir *Charles Scarborough*, my moſt Honoured Friend.

# II. Modern Southern CONSTELLATIONS.

## MONICERUS or UNICORN.

IT is placed between *Orion* the *Great Dog*, and *Hydra*.

## ALECTOR vel GALLUS.

OR the *Cock*, between the *Great Dog*, and the Ship *Argo*.

## COLUMBA.

OR the *Dove* of *Noah*, with an *Olive Branch* in her *Beak*, not far from the *Great Dog*.

## GRUS or the CRANE.

IT consisteth of 13 Stars, whereof Three of the Second Magnitude; one in the *Head*, one in the *Tail* or *Train*; and another in the Southern Wing. This Asterism is also called *Phœnicopterus* and *Genaros*; and it is seated under the Southern *Fish*.

## PHOENIX.

ON her *Spicy Pyre*, consisting of Fifteen Stars; among which there is one in the *Neck* thereof of the Second Magnitude, and two *Nebulous*; It is seated between the Southern *Fish* and *Eridanus*, under *Cauda Ceti*.

## TOUCAN.

OTherwise called the *American Goose*: It is likewise called *Pica Basilica, seu Indica*, and *Ramphestes*: It consists of Eight Stars, whereof Four of the Second Magnitude. This Asterism is placed in the midst between the *Phœnix* and *Indus*.

## INDUS.

OR the *Indian*, in the Figure of an *Indian*, holding in either hand a Dart; and therefore likewise called *Sagittifer*: It consists of Twelve Stars, and is seated between *Toucan*, and the Constellation called *Pavo*.

## PAVO.

THE *Peacock*; or, according to the Greek ταώς; consisting of Sixteen Stars; whereof, one in the *Head* thereof, is of the Second Magnitude, and two *Nebulous*: It is placed near to *Indus*, under *Sagittarius*.

## APOVS.

OR *Apis sive Avis Indica*; *Avis Paradisi*, & *Manu Codiata*; consisting of Twelve Stars: It follows after the *Peacock*, with its *Tail* toward the *Antartick* Pole.

## APIS.

CAlled also *Musca* or *Muia*; and *Crabo Indicus*; cousisting of Four Stars, placed under the *Centaur*.

## TRIANGULUM AVSTRALE.

TRigonium Notius, *sive Deltoton*; to whom some likewise have given the *Arabick* Name of *Almutabet Algenubi*; consisting of Five Stars; in each Angle one of the Second Magnitude, and two others. It is seated *sub fera Centauri & Ara*, called by *Schillerus*, *Signum Tau*; *sive*, *Imago Crucis*; by the Spaniards, *El. Cruziero*.

## CAMÆLEON.

PLaced directly in Opposition to the *Lesser Bear*; and whose Form, (according to the disposition of the Stars which compose it) it represents: It consists of Ten Stars: It is placed directly under the Constellation *Musca* or the *Fly*.

PISCIS

## PISCIS VOLANS.

VOlucris, & Volatilis; calledlike wise *Passer Marinu*; and *Hirundo Marina*; in which last sence it is noted by a new Greek Name *Chelidon Thalassia*; It consists of seven Stars, seated under the Ship *Argo*, next to *Dorado*, or the *Sword-Fish*.

## DORADO.

PIscis Auratus (as the Spaniards call it) *Chrysophris*, or the *Golden Fish*; called likewise *Xiphias seu Gladius*, or the *Sword Fish*: It consists of 6 Stars, with which it Describes and Circumscribes the *Pole* of the *Ecliptick*.

## HYDRUS.

BY the Dutch called the *Wasser Schlange*, consisting of 15 Stars; the last Star in the Tail whereof was in the Year 1600, distant 2 deg. 30 min. from the Southern Pole; but at present (as *Ricciolus* Notes) at a nearer distance.

## V. Of GALAZIA.

IT is that great *White Circle* which is seen in the Heavens in a cold Winters Night (and at other times also) and by the Greeks called *Galazia*; by the Latins *Lactea Via*, or *Lacteus Circulus*; and in English the *Milk Way*.

Concerning this Circle there are sundry Opinions both of Philosophers and Poets, some of which I have here inserted.

The Philosopher *Democritus* affirms the cause of this Circle to be the exceeding great number of Stars in that part of the Heaven, whose Beams meeting together so confusedly, and not coming distinctly unto the Eye, causes us to imagine such a whiteness as is seen.

Others are of Opinion (and the more likely) That this *Milk way* is a part of the *Firmament*, neither so thin as the other parts thereof, nor yet so thick as the Stars themselves: If it were as thin as the other parts of the Heavens besides the Stars, then could it not retain the Light, but the Light would pass through it, and not be seen. If it were as thick as the Stars, then would the Light be so doubled in it, that it would glister and shine as the Stars themselves do: But being neither so thin as the one, nor so thick as the other, it becometh of that whiteness which we see it of.

The

The Poetical Fables concerning this Milky way are many.

*Ovid* ſaith it is the great Cauſey, and the High-way, that leadeth to the Palace of *Jupiter*.

Others ſay, *Jupiter* having begotten *Mercury* on *Maia* the Daughter of *Atlas*, brought the Child when he was Born to the Breaſt of *Juno*, ſhe lying aſleep; but *Juno* awaking, threw the Child out of her Lap, and let the Milk run out of her Breaſts in ſuch abundance, that (ſpreading it ſelf about the Heaven) it made that white Circle which we ſee.

Others ſay, that it was not *Mercury*, but *Hercules* which was laid in the Lap of *Juno*; for *Jupiter* knowing the great hatred that *Juno* bore to the *Babe*, perſwaded himſelf, that if it were poſſible to get her to Nouriſh it, ſhe could not but (as if it were by Nature) bear the *Child* good Will: Hereupon, *Hercules* was brought unto her *Breaſts* as ſhe lay aſleep; *Juno* feeling him to draw very hard, awoke ſuddenly out of her Sleep, threw the *Child* out of her Lap, and let the Milk run down the Heaven, whereby it was Stained White.

Others ſay, That *Juno* did not let her Milk run out of her Breaſts, but that *Hercules* Suck'd them ſo earneſtly, that his Mouth ran over, and ſo this Circle was made.

Others ſay, That *Saturn* being deſirous to devour his Children, his Wife *Ops* preſented him with a Stone wrap'd in a Clout, inſtead of his Child. The Stone ſtuck ſo faſt in *Saturns* Throat, as he would have ſwallowed it, that without doubt he had therewithal been Choaked, had he not been Relieved by his Wife, who by preſſing the Milk out of her Breaſt ſaved his Life: The Milk that miſſed his Mouth fell on the Heaven, and running along made this Circle.

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*The End of the Aſtronomical Part.*

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# RECREATIONS Horometrical.

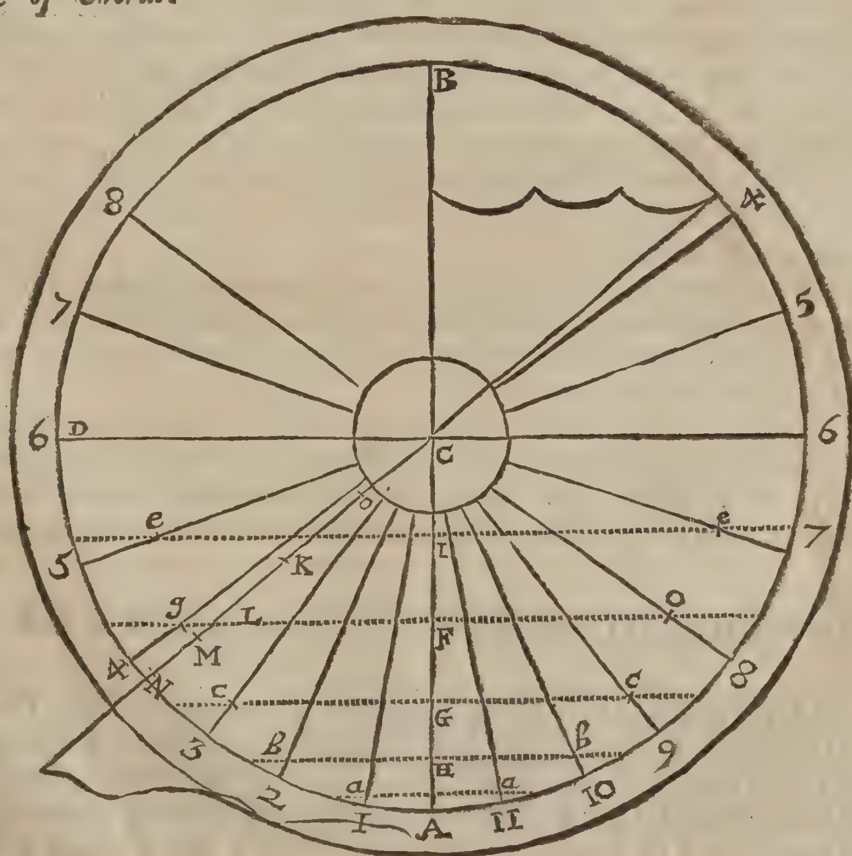
## CHAP. I.

### *How to make an* Horizontal Dial *for any* Latitude, *by help of a Line of* Chords.

HOrizontal Dials are ſuch as are uſually made on *Braſs Plates*, and ſet upon the tops of Poſts in Yards, Gardens, Windows, and other places.

A Line or Scale of *Chords* (by which this and other Dials are made) is ſuch a Line or Scale as is deſcribed in *Geometrical Recreations*, Chap.V. Section II.

*How to make an Horizontal Dial in any* Latitude, *by help of this Scale of Chords.*




 1. With

1. With 60 deg. of the *Chords*, upon the Center C, defcribe a Circle, and divide it into Four equal parts, by the Lines; B C, A for the *Meridian*, or Hour-Line of XII, and D E for the *Prime Vertical Circle*, or Hour-Line of VI.

2. If you would make your *Dial* for the Latitude of 50 degrees ; take 50 deg. out of your *Scale of Chords*, and fet that diftance upon the Circle from A to N, and draw the Line C N, for the *Stile* or *Cock* of your *Dial*.

3. Divide the Two Quarters of your Circle, A E and A D, each of them, into fix equal parts, fo fhall you have in each Quadrant five Points, by which you may draw five *Chord-Lines*, all Parallel to D E, the Line of fix, which will crofs the Line of Twelve C A, in the Points I, F, G, H and A.

4. Take one half of the Line A, and fet it in the Line of the Stile C N, from C to O: From which Point O, take the neareft Extent unto the Line C A. This Diftance fet from A upon the fame *Chord-Line* A, on both fides thereof, at *a* and *a*, through which Points *a* and *a* draw the Lines C *a* and C *a* for the *Hour-Lines* of XI and I of the Clock. In like manner,

| Take half the *Chord-Line*, | H | and fet it from C to | K | and from | K | take the near-eft diftance to C A, and fet it from | H | to | *b b* |
|---|---|---|---|---|---|---|---|---|---|
| | G | | L | | L | | G | | *c c* |
| | F | | M | | M | | F | | *d d* |
| | I | | N | | N | | I | | *e e* |

Which done (which may very fpeedily, and exactly be performed) draw Lines from the Center C through the refpective Points *b b*, *c c*, *d d*, and *e e*, on both fides C A, and they fhall be the true *Hour-Lines* belonging to an *Horizontal Dial*, for the Latitude of 50 *Deg.* that is, the the *Hour-Lines* from fix in the Morning till fix at Night.

5. For the other Hours before and after fix, as four and five in the Morning, and feven and eight at Night, they may be put in, by drawing the *Hour Lines* of four and five in the Afternoon, and feven and eight in the Forenoon, through the Center C, above the Line D E, as is evident by the Figure.

6. If you would infert the Halves and Quarters of Hours, you muft then divide the Two Quadrants into 12 or 24 Equal Parts, and draw *Chord-Lines* through the *Meridian-Line* C A, and deal with them as you did with thofe for the whole Hours.

7. For the Cock or Stile of your Dial, it may be either a Plate of Brafs cut into a Triangular Form, the Pattern whereof is the Triangle C S A, which muft ftand Square (or Perpendicular) upon the *Meridian-Line* C A. Or it may be a Rod of Iron bended to that form.

## *In* Horizontal Dials *obferve thefe following* NOTES.

I. An *Horizontal Dial* in any Latitude, is an upright *South Dial* in that Latitude, which is equal to the Complement of that Latitude for which the *Horizontal Dial* was made——So the foregoing *Horizontal Dial* being made for the Latitude of 50 Deg. take 50 from 90, and there will remain 40 ; fo that the former *Dial* will be a *Direct South Dial* in the

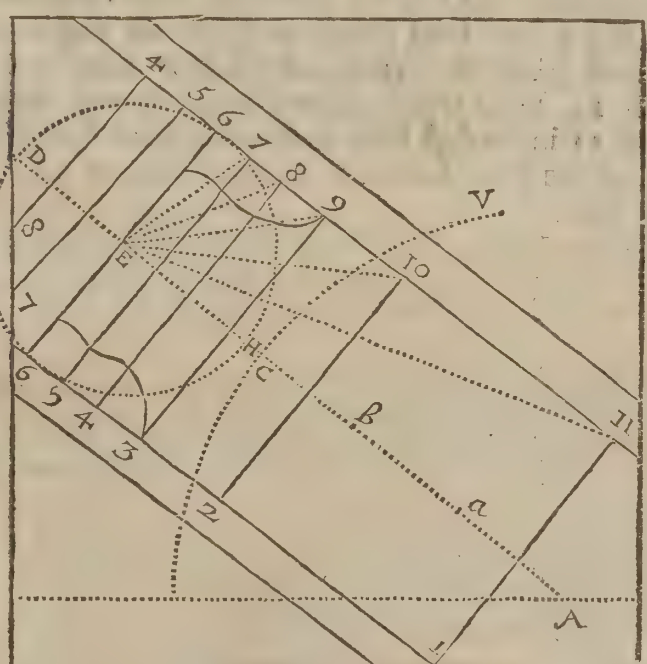
the Latitude of 40 Deg. And the Cock, or Stile, must point downwards towards the *South* Pole.

II. From an Erect Direct *South Dial*, an Erect Direct *North Dial* is deduced :——For, if you draw the *Hour-Lines* (*Stile* and all) of a *South Dial* through the Center, then will 12 at Noon on the *South* be 12 at Midnight in the *North*; and the *Cock*, or *Stile* of the *North Dial* must point upwards towards the *North Pole*; And the *Hour Lines* about 12 at Night (*viz.* 9,10,11,12, 13, 1,2,3.) must be omitted; As in *Fig.* I. all Three Dials are distinguished. So that a *North Dial* is no other than a *South Dial* inverted.

## CHAP. II.

### *To make an Erect Direct* East *or* West Dial.

THese Dials are the same in all Latitudes, and may be made *Geometrically*, after this manner.




Towards the bottom of your Plain, draw an Horizontal Line B A; At the *North end* thereof (as at A,) with 60 deg. of your *Scale of Chords*, describe an Arch of a Circle, as S C V. Then out of your *Scale of Chords* take the Complement of the *Latitude* (in this Example 40 deg.) and set them from S to C, and draw the Line A C D, quite through the Plain; which Line D A divide into five equal parts in the Points a, b, H, E; and with that distance of the Compasses, upon the

point E, deſcribe the Circle D 6 H 6, and through the Center E, draw the Line 6 E 6, at right Angles to the Line A D, and that ſhall be the Hour Line of ſix; And by the Points 6 and 6 draw the Lines 6 11 and 6 1, both parallel to the *Equinoctial Line* A D----Then divide one Quarter of the Circle into ſix equal parts, and laying a Ruler upon the Center E, and each of thoſe parts, it will cut the uppermoſt parallel Line in the points 6, 7, 8, 9, 10 and 11. From which points, if you draw Lines parallel to the Line 6 E 6, they ſhall be the Hour Lines of an *Erect Direct* Eaſt *Plain*. For the Hour-lines before 6 in the Morning and after 6 in the Evening, they are the ſame with thoſe before 6 in the Morning, and before 6 in the Evening: For the diſtance betwixt 6 and 5, is the ſame as is between 6 and 7, and the diſtance between 6 and 4 the ſame as between 6 and 8----For *the Stile of theſe Dials*, it may be a Plate of Braſs, ſo broad as is the diſtance between the Hour-lines of 6 and 9, and muſt be placed perpendicularly upon the Hour-line of ſix. This Plain hath Two Faces, one open to *the Eaſt* (as this in the Figure) the other to the *Weſt*; and one being made the other is made alſo: For, if you prick (or draw) the Lines of the *Eaſt Dial* through the Paper, thoſe Lines on the back ſide ſhall be a *Weſt Dial*, only the *Eaſt Dial* Lines are thoſe of the *Morning* from 4 till 11, and thoſe of the *Weſt Dial* are thoſe of the *Afternoon* from 1 to 8 at Night.

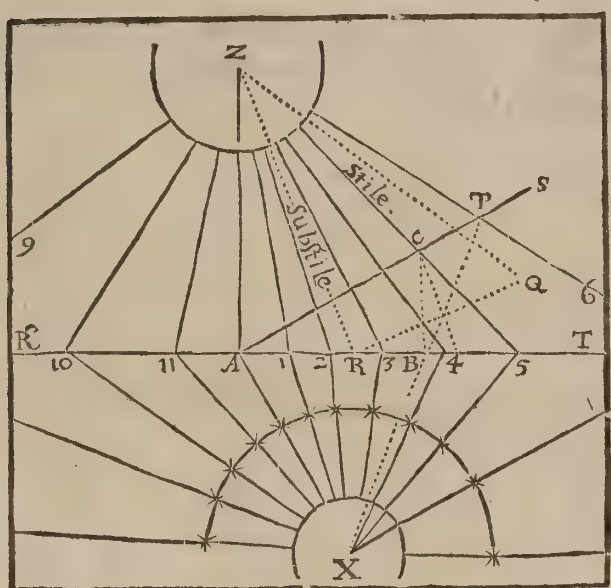
*From an* Eaſt *or* Weſt Dial, *a* Polar Dial *may be deduced.*

Suppoſe the Line A D in the *Eaſt* Dial to lie upon the *Horizontal Line* A B, in the ſame Dial Plain, then will the *Eaſt* Dial be a *Polar* Dial, and muſt behold the *South*, and the *Hour-Line* of 6 muſt be the *Hour-Line* of 12, upon which the *Stile* (or *Cock*) muſt ſtand. And the *Hour-Line* of 11 in the *Eaſt* Dial muſt be the *Hour-Line* of 5 at Night in the *Polar*; and the *Hour-Line* of 1, the *Hour-Line* of 5 in the Morning, in the *Polar* Dial.

CHAP.

## CHAP. III.

### *By help of an* Horizontal Dial, *in any Latitude, to make a* Declining Dial *in that Latitude.*




SUppofe an upright Plain in the *Latitude* of 51 deg. 32 min. to decline from the *South Weftward.* 30 deg.

1. Draw a right line K T, reprefenting the *Bafe or horizontal Line* of your *declining Plain.*

2. In this line, affume any point (as A.) and from it draw another line A S, making an Angle S A T equal to 30 deg. the Plain's declination, (towards K, if the Plain decline *Eaftward)* or towards T, if it decline *Weft*, as here it doth.

3. Upon this point A, erect a Perpendicular to K T. for the meridian line of the *declining Plain*; ----And from the fame point A, another perpendicular to the *Line* A S, for the Meridian (or 12 a Clock line) of the *horizontal Dial*, and in this line affume any point at pleafure (as X) for the Center of the *horizontal Dial.*

4. Upon X defcribe the *Horizontal* Dial K T D E, for the Latitude of 51 *deg.* 32 *min.* and draw the *Stile* thereof X B, continuing it, till it cut the Line A S in P, and all the *Hour-Lines* till they cut the Line K T, in the Points 9, 10, 11, and 1, 2, 3, 4, 5.

5. Make A Z equal to A P; fo fhall Z be the Center of the *Declining Dial.*

6. Upon the Point B, (where the Line X P cutteth the Line K T) erect a Perpendicular, cutting the Line A S in C.

7. Make

7. Make A R equal to B C, and draw the Line Z R for the *Substilar* Line of the *Declining Dial.*

8. From R erect a Perpendicular to Z R, making R Q equal to A B, and draw the Line R Q for *the Stile* of the Declining Dial.

9. From the Center of the Declining Plain Z, draw right Lines from the Center T to the ſeveral Points 9, 10, 11. and 1, 2, 3, 4, 5, &c. (where the Hour-Lines of the *Horizontal* Dial did cut the Line K T;) thoſe Lines ſhall be the true *Hour-Lines* belonging to *the Declining Plain*, and *the Dial* is finiſhed, which you may bring into what form you pleaſe, Round, Square, &c.

And here, for the eaſe of the Practitioner, in making of *Horizontal*, and ſuch other Dials as are hereafter mentioned, I have inſerted this following Table, and its Uſe.

A Table

A Table shewing the Degrees of each Hour-Line from 12, upon all *Horizontal* Dials, from 30 to 60 deg. of Latitude, and for all Direct *North* or *South* Reclining or Inclining Dials, where the Heighth of the Stile of such Dials is between 30 and 60 deg. of Altitude.

| Hours | XI I | | X II | | IX III | | VIII IV | | VII V | |
|---|---|---|---|---|---|---|---|---|---|---|
| Distances from 12. | deg. | m. | deg. | m. | deg. | m. | deg. | m. | deg. | m. |
| Degrees of Latitude, or of the Stiles (or Cocks) Heighth. | | | | | | | | | | |
| 30 | 7 | 37 | 15 | 7 | 26 | 34 | 40 | 54 | 61 | 49 |
| 31 | 7 | 51 | 16 | 34 | 27 | 15 | 41 | 44 | 62 | 30 |
| 32 | 8 | 05 | 17 | 1 | 27 | 55 | 42 | 32 | 63 | 11 |
| 33 | 8 | 19 | 17 | 27 | 28 | 37 | 43 | 20 | 63 | 49 |
| 34 | 8 | 31 | 17 | 54 | 29 | 13 | 44 | 5 | 64 | 24 |
| 35 | 8 | 44 | 18 | 20 | 29 | 50 | 44 | 49 | 64 | 58 |
| 36 | 8 | 57 | 18 | 45 | 30 | 27 | 45 | 31 | 65 | 30 |
| 37 | 9 | 10 | 19 | 9 | 31 | 2 | 46 | 12 | 66 | 10 |
| 38 | 9 | 22 | 19 | 34 | 31 | 37 | 46 | 50 | 66 | 29 |
| 39 | 9 | 24 | 19 | 58 | 32 | 11 | 47 | 28 | 66 | 56 |
| 40 | 9 | 45 | 20 | 21 | 32 | 44 | 48 | 7 | 67 | 21 |
| 41 | 9 | 57 | 20 | 44 | 33 | 16 | 48 | 29 | 67 | 47 |
| 42 | 10 | 10 | 21 | 7 | 33 | 46 | 49 | 12 | 68 | 11 |
| 43 | 10 | 22 | 21 | 29 | 34 | 18 | 49 | 44 | 68 | 33 |
| 44 | 10 | 32 | 21 | 51 | 34 | 47 | 50 | 10 | 68 | 54 |
| 45 | 10 | 43 | 22 | 12 | 35 | 17 | 50 | 46 | 69 | 15 |
| 46 | 10 | 54 | 22 | 33 | 35 | 44 | 51 | 15 | 69 | 35 |
| 47 | 11 | 5 | 22 | 53 | 36 | 11 | 51 | 42 | 69 | 53 |
| 48 | 11 | 17 | 23 | 13 | 36 | 37 | 52 | 9 | 70 | 11 |
| 49 | 11 | 25 | 23 | 33 | 37 | 3 | 52 | 35 | 70 | 28 |
| 50 | 11 | 35 | 23 | 52 | 37 | 28 | 53 | 0 | 70 | 43 |
| 51 | 11 | 45 | 24 | 9 | 37 | 52 | 53 | 21 | 70 | 59 |
| 52 | 11 | 55 | 24 | 27 | 38 | 15 | 53 | 46 | 71 | 13 |
| 53 | 12 | 5 | 24 | 43 | 38 | 37 | 54 | 8 | 71 | 28 |
| 54 | 12 | 13 | 25 | 2 | 38 | 58 | 54 | 29 | 71 | 41 |
| 55 | 12 | 22 | 25 | 10 | 39 | 19 | 54 | 49 | 71 | 54 |
| 56 | 12 | 32 | 25 | 34 | 39 | 40 | 55 | 9 | 72 | 5 |
| 57 | 12 | 40 | 25 | 50 | 39 | 59 | 55 | 28 | 72 | 17 |
| 58 | 12 | 48 | 26 | 5 | 40 | 18 | 55 | 45 | 72 | 28 |
| 59 | 12 | 56 | 26 | 20 | 40 | 36 | 56 | 3 | 72 | 38 |
| 60 | 13 | 4 | 26 | 34 | 40 | 54 | 56 | 19 | 72 | 48 |

*The Use of this Table.*

Suppose you were to make an *Horizontal* Dial for the Latitude of 35 Degrees, and a Direct *South* Dial for the Latitude of 55 deg. Or (which is all one) for any Direct *South* or *North* Dial, *Reclining* where the heighth of the Stile is 35 deg.

First

First draw a downright Line for the *Hour-Line* of 12, and upon any part thereof (towards the upper end) assume a Point for the *Center* of your Dial; and upon that Point with your Compasses opened to 60 deg. of your *Scale of Chords*, describe a *Semicircle*; Then take 90 deg. of your Scale of Chords, and set that distance from the *Hour-Line* of 12, upon the *Semicircle* both ways; and through those Two Points draw another Right Line, which will pass also through the Center, and be the *Hour-Line* of 6 in the *Morning* and 6 in the *Evening*.

Then go to this Table, and look in the first Column thereof for the Latitude 35 deg. and in the Line against 35, towards the Right Hand, you shall find,

| deg. | min. | | Hours | |
|---|---|---|---|---|
| 8 | 44 | to stand under the hours of | XI | I |
| 18 | 20 | | X | II |
| 29 | 50 | | IX | III |
| 44 | 49 | | VIII | IV |
| 64 | 58 | | VII | V |

Which Degrees and Minutes taken out of your *Scale of Chords*, and set upon the *Semicircle* on both sides of the Line of 12, Lines drawn from the Center, through those Points, shall be the true *Hour-Lines* proper for an *Horizontal* Dial for the Latitude of 35 deg. or of a *South* or *North* Dial in the Latitude of 55 deg. and of any Direct *North* or *South* Reclining Dial, where the *Stile*'s Heighth is 35 deg.

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## CHAP. IV.

### *How*, Mechanically, *by help of an* Horizontal Dial *for any Latitude, to describe the* Meridian, Substile, Stile, *and the other* Hour-Lines *upon any other Plain in that* Latitude, Regular *or* Irregular.

1. UNder the Plain upon which you intend to make your Dial; let there be erected a Scaffold of one or more Boards broad (according to the bigness of the New Dial you intend to make,) which Scaffold must be exactly Level, or parallel to the *Horizon*.

2. Being provided of an *Horizontal Dial* with Hours, Halves and Quarters (the larger the better) set it upon the Scaffold, the Center towards the *South*, and the Stile pointing up towards the *North* Pole; then

3. Having attained the true *Hour of the Day*, either by some true *Sun-Dial*, a *Solar Observation* by *Quadrant*, *Ring*, or other *Instrument*, or by a good *Minute-Watch* well rectified;

4. Bring *the Horizontal Dial* upon the Scaffold to the True Hour and Minute of the Day, at such convenient distance from the *Plain* as your Judgment will direct you; and there with small Tacks, or Cement, fix your Dial upon the Scaffold, so that it move not; there being a small string fixed in the Center of the Dial. Then,

5. Extend the Thread, which is in the Center of the Dial, along, justly, to touch the Top of the Stile of the Dial, till it doth touch the New Dial Plain, and note that Point; for that shall be the *Center* of the New Dial: The Thread it self is *the Stile* or *Axis*, and the Line under it (which may be found by help of a *Carpenter's* Square applied to the Plain and the String) is the *Substilar Line* upon the Plain, by help of which the Stile may be made and fastned.

6. To draw the Hour Lines: Extend the Thread fixed in the Center of the *Horizontal Dial*, over every Hour (Half and Quarter, if you will) till the Thread do touch the *Plain* upon the *Horizontal Line* thereof, (which will always be in the same Level with the upper part of the Scaffold,) and where they intersect this Line (or the Plain,) make Marks, noting them with the same Figures as the Thread passed over in the *Horizontal* Dial: So Lines drawn from the Center of the New Dial, through these Points, shall be the true Hour Lines of the New Dial.

*But some Hour-Lines may run beyond the Limits of the Plain, or the passage of the Thread may be obstructed by some Objects, or Irregularities in the way, that it cannot come to touch the Plain; Then to help these, or the like Impediments,*

7. Upon the *Horizontal* Scaffold, draw as large a *Square*, or *Parallelogram* as you can (or you may extend the Hour-Lines of the *Horizontal Dial* upon the Scaffold it self) and transfer (by help of the Center-Thread) all the hours of the *Horizontal* Dial into the sides of the *Square* or *Parallelogram:* And then,

8. Bring a Thread from the Center of the New Dial, and rest it upon the Hour-Point marked in the side of the *Square* or *Parallelogram:* Then the Thread in the Center of the *Horizontal* Dial carried along, so as only to touch the other Thread from the Center, will describe the Hour-Line desired, whether upon an *Even* or *Uneven Plain*, from the Center of the New Dial.

*Thus far for* Dials *whose Centers will fall within their Plains; but for such as decline much from the* South *towards the* East *or* West, *in such the Thread which passeth from the Center of the* Horizontal Dial, *by the side of the* Stile *thereof, the Thread will not meet with the Plain at all, or (at least) not in a great distance, so that no Center can be found upon the Plain it self. In such Cases you must,*

9. Set up a *Board* or other *Object*, over, or on that side of the *Plain* towards which the *Axis* tendeth, to receive the Center; and then, fixing a Thread there, by that, and the other Thread you may describe all the Hour-Lines, as was before shewed in *Irregular Plains:* And the Thread from the Center will be the true *Axis* or *Gnomon* of the *Dial*, and must be fixed to the Wall by two Stays.

# CHAP. V.

## Of Projective Dials.

BY this Artifice *Hour-Lines* may be Projected upon all kinds of *Superficies*, without any regard had to their ſtanding; either in reſpect of *Declination*, *Reclination*, or *both*; Or whether the *Plains* be *Flat* or *Curved*; *One* or *more*: For if a *Point* be aſſigned, wherein the *Hour-Lines* and *Axis* ſhall concur, *Hour-Lines* may be Projected upon ſuch *Plains*, and an *Axis* ſet up after the uſual manner, by the directions following.

*Firſt*, To the *Point* aſſigned (upon any ſide of it) by help of a *Semicircle*, or other *Level*, ſtretch out an Horizontal Thread, ſerving for the Horizontal Line, which *Line* (or *Thread*) need not be one ſingle Line, but may be returned by Two, Three, or more Angles, provided that all the parts of it do lie in the ſame Superficies, and parallel to the Horizon.

*Secondly*, With a Perpendicular Thread held up, project the Sun into the aſſigned Point, and into the Horizontal Thread alſo, and there ſtick in a Pin, or make a Mark upon the Horizontal Line, through which the Shadow cutteth; and at the ſame Inſtant alſo take the Sun's *Altitude*.

*Thirdly*, By the *Altitude* taken, find out the Sun's *Azimuth* for that time. This *Azimuth*, whatever it be, is repreſented by the *Mark* before made in the Horizontal Line or Thread.

*Fourthly*, Apply a Paiſtboard to the aſſigned Point, holding it flat, that it may lie in the ſame Plain with the Horizontal Thread; and upon this Paiſtboard protract your *Azimuth*, by a Thread extended from the Point aſſigned for the *Center*, to the *Mark* made upon the Horizontal Thread. This done,

*Fifthly*, By help of that *Azimuth* upon the *Paiſtboard*, protract the *Meridian Line*, obſerving the true *Coaſt*; and to the *Meridian* thus found, deſcribe an Horizontal Dial for the place.

*Sixthly*, Apply the *Paiſtboard* to its place again, all things ſtanding right as before, project all the Hour-Lines into the Horizontal Thread from the *Paiſtboard*, and make Marks upon the Horizontal Line from the Points of each ſeveral Hour.

*Seventhly*, Project the *Meridian Point* by a Perpendicular Thread upon ſome Object, into that place whereabouts you imagine the *Axis* of the World would paſs, whether it be above or below, from the Point aſſigned for *the Center*.

*Eighthly*, By help of a *Semicircle* (or a *Quadrant* applied to a String) elevated, or depreſſed (as occaſion offers) from *the Point* aſſigned for *the Center*, according to your *Latitude*, project the *Pole of the World*.

*Ninthly*, Extend a *Thread* from the Point aſſigned for *the Center* to *the Pole of the World*, which *Thread* will repreſent the *Axis*.

*Tenthly*, By the Points upon *the Horizontal Thread*, and *the Axis*, (either by your *Eye*, laying *the Axis* to the Hour-Points, or laying the Hour-Points to *the Axis*,) you may project all the Hours----Or without *the Axis* you may content your self with the Pole-Point projected into *the Meridian*: For, if from the Point assigned for *the Center*, or meeting of the Hours and *Axis*, you extend a *Thread* to each Hour-Point in the Horizontal Line, and do repose (by your *Eye*) the same *Thread* upon the Pole Point, then shall the Shadow of *the Thread* give you that Hour Line; and so you may do for all the rest.

*Eleventhly*, Your *Thread* or *Axis*, lying in its true situation, you may easily fit an *Axis* to the same posture. If your Dial be described upon a Plain *Superficies*, you may then (by one side of a *Square*, applied to *the Thread* or *Axis*, and the other side lying upon the Plain,) find out the *Substile*. ----But if the *Dial* be described upon a *Curved Superficies*, or upon more than *One*, then must you be content to set up your *Axis* by the direction of *the Thread* only.

*Twelfthly*, The Point assigned for *the Center* being a Point of *the Axis*, is, as it were, *the Apex* of *the Gnomon*, unto which all *the Work is projected*. But if it be required to set up an *Axis* to such a *Superficies* upon which the Hours and *Axis* will not meet at any tolerable distance; in such a case set up any point (of *Wyre*, or such like) of such distance from the *Superficies*, as that the Hours and *Axis* may be distinct, and through that *point* let it be required to make *the Axis* pass. You have no more to do, but only to project to this *point*, as before, by letting the *shadow* of a perpendicular Thread pass through that *point*, and noting the same upon the Horizontal Thread; and counting that end of the *Wyre* as your *Center*, proceed as before; for the *Thread* that lies to project the Hours is a *Pattern* for *the Axis*.

Now this is a *General* way to project Hour-lines upon *one*, or *many Superficies*, be they *plain* or *curved*, *one* or *more*, and that without any laborious Inquisition of any of their situations, in respect of *Declination*, *Reclination*, or *both*.

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## CHAP. VI.

### Of Reflected Dials.

IF a piece of *Looking-Glaſs* (of about one third part of an Inch diameter) be Horizontally fixed upon *the Soyle* or *Tranſome* of any *Window*, unto which *the Sun* hath free acceſs; you may draw *Hour lines* upon any Plain, whether *Horizontal*, *Reclining*, or *Inclining*, be they *one* or *more*; by which the true Hour of the day may be diſcovered by *the ſpot of Light* which the Sun ſhall reflect from *the Glaſs* upon any of *the Plains*: And that by theſe Precepts following.

*Firſt*, The *Glaſs* being plac'd truly Horizontal, obſerve *the ſpot of Light* that the Sun caſts, and make a Mark at it.

*Secondly*, And at the ſame time take the Sun's *Altitude*, and find its *Azimuth*.

*Thirdly*, Extend an *horizontal Thread* in the ſame *Level* with the *Glaſs*, but within the Room.

*Fourthly*, Project *the Azimuth* into *the horizontal Thread*, by holding up a perpendicular Thread in ſuch a place, that, though it hang at liberty, you may at once diſcern both *the Mark of the ſpot of Light*, and the *Glaſs* likewiſe; and then obſerve where *the perpendicular Thread* ſeems to cut *the horizontal Thread*; and at that apparent interſection, make a *mark* upon *the horizontal Thread* for *the Azimuth*.

*Fifthly*, Apply a *Paiſtboard* to *the Glaſs*, ſo that it may be ſtayed upon ſome *Reſt*, that after it is taken away, it may be reſtored to its place again, without any alteration. Let it be alſo placed *horizontal*, ſo that it may have full relation to the *horizontal Thread*.

*Sixthly*, At the *Glaſſes Center* make a Point for *the Center* upon the *Paiſtboard*, and extend a *Thread* from the *Center* upon the *Paiſtboard*, till it touch the *Mark* made for the *Azimuth* upon *the horizontal Thread*, and draw upon *the Paiſtboard* that Line which the extended *Thread* figures out thereupon: Afterwards, unto the ſame *Azimuth* upon the *Paiſtboard*, draw a *Meridian Line*, and to it an *horizontal Dial* for the *place*; and applying the Paiſtboard again to its former ſituation, project *the hours* thereon unto *the horizontal Thread*, and there make *Marks*, or tie *Knots*.

*Seventhly*, Then project *the Meridian* (by a *perpendicular Thread*, covering, in appearance, both *the Mark* at 12, and *the Glaſs*) unto the contrary *Coaſt*, to that wherein the Pole is elevated above the Horizon; that is to ſay, In our *Northern* Climates you muſt project *the Meridian Southward* from *the Glaſs*, becauſe the *North Pole* is elevated: And in this *Meridian* elevate your *Semicircle* or *Quadrant* from *the Glaſs Southwards*, till the *Plummet* fall upon the *Latitude*; ſo ſhall it point out, upon ſome Object ſet to receive it, the *North Pole Reflected*.----Or elſe, if this be not convenient, (becauſe in Windows which look towards the *South*, the *North Pole* will be without the Room, and ſo the *Axis* above the *Glaſs* extended towards that *Pole*, will be without alſo,) you may

may in such Cases, find out *the opposite Pole* to it; that is to say, that Pole which the former *Reflected Axis*, being extended through the *Glass*, and below it, would sign out; and that may be effected in this manner.

*Eighthly*, Project the *Meridian-line* towards the Pole that is elevated; that is with us, towards the *North* Pole; and then (because the *North* Pole is elevated by *Reflection*, towards the *South*, so, by the same Reason, the *South* Pole must be depressed towards the *North*) by your *Semicircle* or *Quadrant*, and String directed even with *the Center of the Glass*, express or project your Latitude downwards (but towards the *North*,) so shall the *Semicircle*, or *Thread*, point out the *Reflected South* Pole in the *Meridian*. Now, whether you will, or can (most conveniently) use the *Reflected North* Pole above the *Glass*, or the *Reflected South* Pole below it, you are to take your choice; for both the one and the other of them do represent the *Reflected Axis of the World*.

*Ninthly*, By this *Reflected Axis*, and the *Hour-points* signed out upon the *horizontal Thread*, you may easily project the *Reflected Hours*, upon any kind of *Superficies*, *one* or *more*, whatever they be that stand in the way.

## CHAP. VII.

### *How* (Mechanically) *by help of a* Trigon, *to inscribe the* Equinoctial, Tropicks, *and the other Signs and* Parallels *of* Declination, *upon all sorts of* Sun-Dials: *As also the* Azimuths, *or Points of the Mariners Compass; the* Almicanters, *or Circles of the* Sun's Altitude, *&c.*

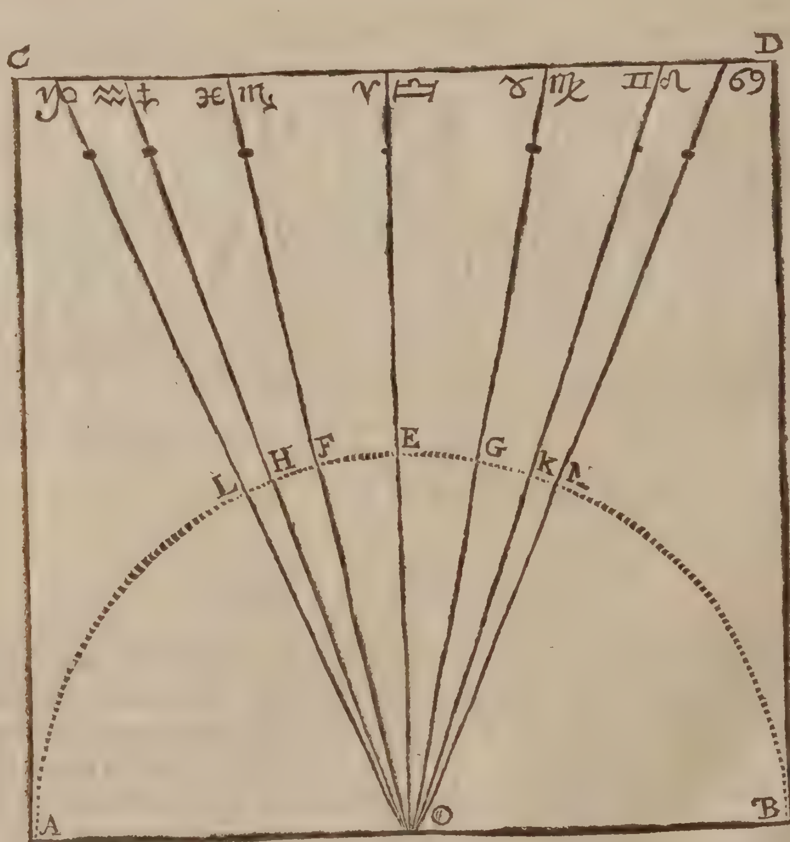
#### I. *How to make the* Trigon.

THE *Trigon* may be made upon a piece of thin Board, or Sheet of Paistboard, as is the Figure A B C D; Through the middle whereof draw the Right Line ⊙ E ♎, representing the *Equinoctial Circle* in the Heavens; then upon ⊙, as a *Center*, with 60 deg. of your *Scale of Chords*, describe the Semicircle A E B; Then out of your *Chord* take 23 deg. 30 min. the quantity of the Sun's greatest *Declination*, and set them from E, on both sides of the *Equinoctial* to L and M, and draw the Two lines ⊙ M ♋, and ⊙ L ♑, for the Two *Tropicks*; Then for the other intermediate Signs, set off 11 deg. 30 min. from E, both ways, to F and G, and draw the lines ⊙ F ♏, and ⊙ G ♉, for the lines of the Sun's Entrance into the Sign ♏ and ♓, and into ♉ and ♍---- Also, take 20 deg. 12 min. from the Scale of *Chords*, and set them from E,

E, on both sides, to H and K, and draw the lines ⊙ H ♒, and ⊙ K ♌ for the lines of the Sun's Entrance into the Signs ♒ and ♐, and into ♊ and ♌---Then towards the upper ends of the several lines, ⊙ L, ⊙ H, ⊙ F, ⊙ E, ⊙ G, ⊙ K, ⊙ M, make small Holes, through which to put a small String: And thus is your *Trigon* finished, and fitted for the inserting of the Parallels of the Twelve Signs into all sorts of Sun-Dials, either *Direct* or *Reclining*, *One* or *more*, *Contiguous* or *Separate* :-----But if you would put in other *Parallels* of *Declination*, as such as when the Days are just 8, 9, 10, 11, 12, 13, 14, 15 or 16 Hours long, Then you must insert into your *Trigon* such degrees of *Declination* as the Sun hath when the Day is so many Hours long, as you would describe upon your Dial: And so in the Latitude of *London*,

| | | | | | deg. | min | |
|---|---|---|---|---|---|---|---|
| When the day is either | 8 | or | 16 | Hours long, the Sun hath | 21 | 40 | Degrees of Declination. |
| | 9 | | 15 | | 16 | 55 | |
| | 10 | | 14 | | 11 | 37 | |
| | 11 | | 13 | | 5 | 55 | |

And such degrees of *Declination* you must put into the *Trigon*, between the *Equinoctial* and the *Tropicks*.




II. *How*

## II. *How to insert the* Equinoctial, *the* Tropicks, *and other Intermediate* Parallels *of* Declination *into all sorts of* Dials.

YOU are to Note, that the *Parallels* of the *Signs*, the *Diurnal Arches*, the *Azimuths*, the *Circles* of *Altitude*, and all other *Circles* relating to the Course of the *Sun*, when they are described upon any *Sun-Dial*, are not shadowed out by the whole *Stile* or *Axis* of the *Dial*, as the *Hours* are, but by some One Point in the same *Axis*; as by a *Knob*, *Button* or *Notch*, filed in the *Stile* of the *Dial*; Or by a *hole* in a *Glass Window* for *projected Dials*; or by a piece of *Looking-Glass* for *Reflected Dials*; in all which Cases, the *Center* ⊙, in the *Trigon*, is to be applied (in all Cases,) so that the line A B thereof, must lie upon the *Stile* of the Dial (if the Dial have a *Stile*) or Parallel to the *Axis* of the World, if it be an *hole* in a *Window*, or piece of *Looking-Glass*: And now, the *Trigon* being thus disposed, so that it may be turned about the *Axis*, the *Center* ⊙ always fixed in the same point.

Now suppose you would insert the *Equinoctial* into any Dial,(for one *Rule* serves for all *Plains*:) *First*, put a long small String through the Hole which is under ♈ ♎, tying a Knot on the back side, that it slip not through the Hole in the Board; Then apply the *Center* ⊙ to the *Point* (or *Button*) in the Stile, and the Side A B to the Stile it self. Now if you extend the Thread over the Line ♈ ♎ E ⊙, till it touch the *Dial-Plain*, that point of touching shall be one point through which the *Equinoctial* is to be drawn upon the Plain——Then turn the Line A B about upon the Stile, leaning either towards the Right or Left Hand, as occasion offers it self, extend the Thread till it touch the Dial-Plain in some other point, and that other point shall be another point through which the *Equinoctial* is to be drawn upon the *Dial*. And if your *Dial* be all but one plain *Superficies*, Two points will be sufficient to draw the *Equinoctial* by, it being a *Great Circle* of the *Sphere*, and so a *Right Line* upon all *plain Superficies*; But if *the Dial* consist of more than one *Plain*, then must you (in the same manner as before) find two points at least upon each *Superficies*; which you may easily and speedily do, by turning the line A B of the *Trigon* about (or parallel to) the *Axis*, and extending the Thread over the line ♈ ♎ E ⊙, till it touch the Plain.

In like manner, if you would insert the *Tropick* of *Capricorn* into your *Dial*, you must put the String or Thread through the Hole under ♑, and then apply the Point ⊙ to the Point in the *Axis*, and the Side A B to the Stile, extend the Thread over the line ♑ L ⊙, till it touch the Plain, and that point of Touch shall be one Point through which *the Tropick* of *Capricorn* is to be drawn-- -Again, Move *the Trigon* (in this position) towards the Right or Left Hand (as occasion requires,) extend the Thread over the same Line ♑ L ⊙, till it touch the Plain, and that shall be another point through which that *Tropick* must be drawn; And in this manner may you find as many points upon the Plain as you please, and the more the better (for these *Parallels* will not be streight lines, as *the Equinoctial line* was, but *Conick Sections*, or *Curved lines*) through which points a line being traced, with an even Hand, shall be *the Tropick* of *Capricorn* upon your *Dial-Plain* or *Plains*.

And

And in this manner may the *Tropick* of *Cancer*, and all *the parallels* of the other Signs be drawn, if first you put the String through the respective Holes, and apply the *Trigon* to the *Axis*, and extend the Thread till it touch the Plain, as before, you may find as many points as you please, through which to draw your *parallel*. And let this suffice for the Inscription of *the parallels* of the Signs of *the Zodiack*.------And if you would insert the *parallels* for the length of the Day, they are to be done in the same manner, if instead of *the Declination* for the Signs, you put into your *Trigon* the *Declinations* answering to the *length of the days* you intend to insert into your Plain, as is before directed.

## III. *To insert the* Parallels *of the* Sun's Altitude *into all* Projected or Reflected Dials.

THis may be performed by a *Quadrant* drawn upon a large piece of Board, or Sheet of Paistboard, and divided into 90 Deg. after the usual manner. For if you apply a Board, or other matter to *the Glass* (if a *Reflected Dial*; or to *the Hole*, if it be a *projected Dial*) so that it may lie exactly level, or parallel to *the Horizon*; Which Board thus fixed, apply the *Center* of *the Quadrant* to *the Center* of *the Glass* or *Hole*, setting one side of *the Quadrant perpendicular*, the other *parallel* to *the Horizon*, and a small *String* or *Thread* in *the Center*: Then consider what *Circle of Altitude* you would describe upon your *Dial-plain* or *plains*, (suppose 30 degrees:) The *Quadrant* standing in the fore-said posture, upon any part of *the Horizontal Board*, extend the *Thread* by *the Superficies* of *the Quadrant* over 30 deg. thereof, till it touch *the Wall* or *Ceiling of the Room*, and where it touches any Object that is in the way, that point of touch shall be one point through which *the parallel* of 30 degrees of *Altitude* shall pass.-----Again, Move *the Quadrant* (*the Center* being still kept in *the Center of the Glass* or *Hole*, but *the Horizontal side* moved to some other part of the fixed Board) extend *the Thread* again over 30 deg. of *the Quadrant* till it touch *the Wall* or *Ceiling of the Room*, and that shall be another point through which the *parallel* of 30 deg. of *Altitude* shall pass. And in this manner may you find as many points as you please, by which to describe that *parallel*------ If both *the Glass* and *Ceiling* be both *Horizontal*, then these *parallels of Altitude* will be perfect *Circles*, whose *Center* will be in *the Vertical point* directly over *the Glass*, and in the same Plain with *the Ceiling*. But if the Plains be *Upright*, or *Reclining*, then these *parallels* will be *Curved Lines*, as *the parallels* of *the Signs*, and must be drawn through the respective points found with an even Hand----And as this *parallel* of 30 deg. of *Altitude* was drawn, so may any other, as of 10, 20, 40, 50, &c. be, by extending *the String* in *the Center* over those degrees in *the Quadrant* till they meet with the Plain.

IV. *How*

## IV. *How the* Azimuths, *or* Vertical Circles *may be described upon all sorts of Plains.*

FOR the performance of this Work, you muſt firſt find a *Vertical point*, above, tending to *the Zenith* of *the Glaſs* (if it be for a *Reflected Dial*; Or below, towards *the Nadir* of *the hole*, if it be a *Projected Dial.*) This Point thus found (which may be done by a Plumb Line, or perpendicular Thread from *the Ceiling* to *the Glaſs*, or from the *Hole* to the *Floor*) may be called *the Reflected Vertical point*, in which a *Thread* or *String* is to be fixed: And by a point found in *the Reflected Axis* of *the Horizon* the *Azimuths* may be drawn; as *the Hours* were by a point found in *the Reflected Axis* of *the* Equinoctial: In manner following:

Upon a Sheet of Paiſtboard, or like Material, let there be deſcribed ſuch *Azimuth Circles* as you intend to deſcribe upon your Plain; whether they be *the Degrees* of *the Horizon*, or *the points of the Mariners Compaſs*: for both are put on by the ſame Method, only vary in their Denomination. One being numbered by 10, 20, 30, &c. the other by *South*, *S by W*, *S S W*, *&c.*

Theſe *Azimuth Lines* being drawn upon the Paiſtboard, place the *Center* of them upon *the Center* of *the Glaſs*, and *the South Azimuth* thereof upon *the Meridian* of the place, ſo that the Paiſtboard may be there fixed in the very Plain of *the Horizon*, that is, perfectly *horizontal* or *level.*

Then take *the Thread* which is fixed in *the Glaſs*, and draw it over any *Azimuth* marked on the Paiſtboard, till it meet with ſome Object in the Room, as a *Poſt*, *Wall*, or the like, and there fix it.

Then take *the Thread* whoſe end is fixed in *the Reflected Vertical point* over *the Glaſs*, and lead it along by *the horizontal Thread*, till it meet with *the Wall* or *Ceiling* of *the Room*; and where it toucheth, that ſhall be one point through which that *Azimuth* muſt be drawn. In like manner, move the ſame *Thread* higher or lower at pleaſure, by the ſide of *the horizontal Thread*, till it be oppoſed by ſome *Wall* or *Ceiling*, and there make another Mark for a ſecond point, through which that *Azimuth* muſt be drawn: And now have you Two Points, the which (if they fall both upon one and the ſame *Superficies*, *Wall* or *Ceiling*,) are ſufficient; for *the Azimuths* being *Great Circles* of *the Sphere*, will be ſtreight Lines; and ſo may you find Two Points upon each *Superficies*, if there be more than One: Or, by the firſt Two Points, if a *Thread* be ſo ſituated, that it may interpoſe between *the Eye*, and the ſaid *Two Points*, you may make as many Points as you pleaſe upon all *the Superficies*, be they never ſo many: And in this manner may what *Azimuths* you pleaſe be inſcribed upon any Plain or Plains.

Note, *In all the* Reflected Dials *mentioned in this* Chapter; *although the* Plains *themſelves may be many, and thoſe* Regular *or* Irregular, Contiguous *or* Separate; *yet (in all Caſes) the* Glaſs *muſt lie level or parallel to the* Horizon; *which is a thing very difficult to effect by any* Inſtrument, *the* Glaſs *being ſo ſmall*; *Wherefore One* Mechanical *way may be this, which I think is inferior to none:*

In the Hole made in *the Transome* of *the Window*, in which *the Glass* is to be fixed, pour some Drops of Fair Water, or other Liquor, till the Hole be full; then, the Sun shining, will cast *the Reflex* thereof upon *the Ceiling*, which point of *Reflected Light* mark upon *the Ceiling*, and incontinently, with a Spunge, dry up the Water which is in the Hole: Aud having *Cement* (or the like) to fasten *the Glass* with, put it in the Hole, and *the Glass* upon it, and while *the Cement* is yet warm and pliable, move *the Glass* upon it till it cast its shadow upon that point of *the Ceiling* to which *the Water* was *Reflected*; and by this means shall your *Glass* be truly placed.

---

## CHAP. VIII.

### *Of* Dials *which shall give the Hour of the Day by the* Sun, *and by the* Stars *in the Night-Season: How such* Dials *may be made, and how to make Use of them.*

There are several ways by which any *Stars* Horary distance from the Meridian (call'd the *Stars* Hour) may be obtained: As,

#### I. *By any* Quadrant, *or other Instrumental* Dial, *which giveth the Hour of the Day by the* Sun.

I Will Illustrate this in the Use of Mr. *Gunter's Quadrant*, it being an Instrument more frequently known than any other of that kind: For,

If you observe the same Rules in finding the *Stars* Hour, as is directed for finding of the Hour of the Day by the *Sun*; that is, by setting the Bead to *the Stars Declination*, instead of *the Sun's Declination*, and then observe *the Stars Altitude*, as if it were *the Sun's Altitude*, the Bead shall then shew among the Hour-Lines the *Stars* Hour, or *the Stars Horary distance* from *the Meridian.*

But here you are to note, *That this way of finding the* Stars *Hours is peculiar to such* Stars *only as are between the* Tropicks. *Wherefore, another more general way may be this:*

II. By

## II. *By a* Sun-Dial *made under the* Soyl, *and on the* Jaums *of a* Jetty *Window, on the inside of a Room.*

And ſuch a *Dial* may be made by the Rules before given in *Chap.* V. hereof; Or thus:

HAving made a ſmall round hole in any Quarry of Glaſs in the Window, and darkned the other part of the ſame Quarry round about the hole, you muſt upon the Window-Board draw a Meridian Line, which Line muſt paſs directly under the hole before made, and muſt be transferred to the Ceiling of the ſame Room, by the help of Perpendicular Threads.

Then from the hole in the Window, to the Meridian Line on the Ceiling, extend a String, till it make an Angle equal to the *Latitude* of the place you make the *Dial* in, and where the String (with this condition) ſo reſteth, fix the end of the String in that point of the Ceiling, letting the other part of the *String* hang at liberty.

This done, by help of an *Horizontal Dyal*, whoſe Center (for the preſent) muſt be placed in the hole in the Window; the Lines of which *Dial* muſt alſo be extended by a Thread fixed in the Center thereof by which Line extended over each Hour, and the String before fixed in the Ceiling, the Hour Lines may be transferred and marked upon, or under the Window Board; and alſo upon the *Jaums* and *Cheek Poſts* of the ſaid Window, and there numbred by Letters or Figures.

Now ſuch a *Dial* being made, I ſhall ſhew,

### *How to find the Hour by the* Sun *in the day time, and any* Stars *Hour (or* Horary *diſtance from the Meridian) in the Night Seaſon.*

#### 1. *By the* Sun.

THE *Sun* ſhining through the hole before made in the Window, move the String, whoſe end is fixed in Ceiling, along the Hour Points which are marked about the Window, until ſuch time that the Spot of Light that cometh through the hole ſhineth upon the String, and then ſee upon what Hour, or part of an Hour the ſtring reſteth, for that is the true time of the Day.

#### 2. *By the* Stars.

THis differeth little from the former; for when through the Window you ſee a *Star* you know, and would know his Hour, move the String along the Hour Points as before, till ſuch time as you bring your Eye, the String, the Hole, and the *Star* all in one and the ſame Plain or right Line; for then will the String reſt upon that *Stars* Hour, or his *Horary* diſtance from the Meridian.

### III. *By a* Dial *made in a Yard or Garden.*

IN ſome convenient open place erect a Pole perpendicular to the *Horizon*, about 10 or 12 foot high; then provide a Frame of Wood in form of a *Parallelogram*, of what bigneſs you pleaſe, (but the ſides being 2 foot broad, and 3 foot long, is a competent bigneſs;) within the *Area* of this Frame make the true Hour-Lines of an *Eaſt* and *Weſt* Dial; which Hour-Lines may be of reaſonable big Wyre; and upon the Edges of the Frame, ſet the Numbers of the Hours, the Forenoon Hours on the *Eaſt* ſide, and the Afternoon Hours on the *Weſt* ſide, and over the Hour-Line of Six erect an *Axis* (of a competent Length) as if it were a *Sun-Dial*: Which Dial being thus prepared, if you ſet it upon the former erected Pole, ſo that the Two Ends of the Frame may ſtand due *North* and *South*, and the Stile thereof Parallel to *the Axis* of the World, then is it fit for uſe, either to find the Hour of the Day by the *Sun*, or *the Stars* Hour in the Night.

#### 1. *By the* Sun.

THis is all one as if it were a *Dial* made againſt a Wall; for the ſhadow of *the Axis* upon the Frame will ſhew the Hour of the Day.

#### 2. *By the* Stars.

WHen you ſee a *Star* you know, and would find that *Stars* Hour; move your ſelf about the Dial-Poſt (coming near to it, or going farther from it) as occaſion offereth, till you bring your Eye, the *Axis*, and the *Star* in the ſame Plain or Right Line, and then mind what Hour-Line (or between what Hour-Lines) is intercepted by that view, for that is that *Stars* Hour; and by this *Dial* you may at any time know what *Stars* are upon *the Meridian*.

### IV. *To know what* Stars *are upon the Meridian.*

IF you go behind *the North* End of the Frame, and look by the ſide of the Frame, you ſhall ſee what *Stars* are then upon *the South* part of *the Meridian*.

And if you go behind *the South* End of the Frame, and look by the Side of the Frame, you ſhall there ſee what Stars are upon *the North* part of *the Meridian*.

*And thus the* Stars Hour *may be found by any of the forementioned ways: which obtained, the true* Hour of the Night *may be found: But firſt you muſt know the* Right Aſcenſion *of the* Sun, *and alſo of the* Star, *whoſe* Hour *you found by your* Dial. *And to that end I have inſerted the Two following Tables.*

A Table of the Complement of the Sun's Right Aſcenſion at Midnight, every Night in the Year.

| | *Jan.* | | *Feb.* | | *March* | | *April* | | *May* | | *June* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Days | h. | m. | h. | m. | h. | m. | h. | m. | h. | m. | h. | m. |
| 1 | 4 | 25 | 2 | 18 | 0 | 32 | 10 | 39 | 8 | 46 | 6 | 41 |
| 2 | 4 | 21 | 2 | 14 | 0 | 28 | 10 | 35 | 8 | 42 | 6 | 37 |
| 3 | 4 | 17 | 2 | 10 | 0 | 24 | 10 | 31 | 8 | 38 | 6 | 33 |
| 4 | 4 | 13 | 2 | 6 | 0 | 21 | 10 | 27 | 8 | 34 | 6 | 29 |
| 5 | 4 | 9 | 2 | 2 | 0 | 17 | 10 | 24 | 8 | 30 | 6 | 24 |
| 6 | 4 | 4 | 1 | 58 | 0 | 14 | 10 | 20 | 8 | 26 | 6 | 20 |
| 7 | 4 | 0 | 1 | 54 | 0 | 10 | 10 | 16 | 8 | 22 | 6 | 16 |
| 8 | 3 | 56 | 1 | 50 | 0 | 7 | 10 | 13 | 8 | 18 | 6 | 12 |
| 9 | 3 | 51 | 1 | 46 | 0 | 3 | 10 | 9 | 8 | 14 | 6 | 8 |
| 10 | 3 | 47 | 1 | 43 | 11 | 59 | 10 | 6 | 8 | 10 | 6 | 4 |
| 11 | 3 | 43 | 1 | 39 | 11 | 55 | 10 | 2 | 8 | 6 | 6 | 0 |
| 12 | 3 | 38 | 1 | 35 | 11 | 52 | 9 | 58 | 8 | 2 | 5 | 56 |
| 13 | 3 | 34 | 1 | 31 | 11 | 48 | 9 | 54 | 7 | 58 | 5 | 52 |
| 14 | 3 | 30 | 1 | 27 | 11 | 45 | 9 | 50 | 7 | 54 | 5 | 48 |
| 15 | 3 | 26 | 1 | 24 | 11 | 41 | 9 | 47 | 7 | 50 | 5 | 43 |
| 16 | 3 | 22 | 1 | 20 | 11 | 37 | 9 | 43 | 7 | 46 | 5 | 39 |
| 17 | 3 | 18 | 1 | 16 | 11 | 34 | 9 | 39 | 7 | 42 | 5 | 35 |
| 18 | 3 | 14 | 1 | 12 | 11 | 39 | 9 | 35 | 7 | 38 | 5 | 31 |
| 19 | 3 | 10 | 1 | 8 | 11 | 27 | 9 | 31 | 7 | 34 | 5 | 27 |
| 20 | 3 | 6 | 1 | 5 | 11 | 23 | 9 | 28 | 7 | 30 | 5 | 22 |
| 21 | 3 | 2 | 1 | 1 | 11 | 19 | 9 | 24 | 7 | 26 | 5 | 18 |
| 22 | 2 | 57 | 0 | 57 | 11 | 16 | 9 | 20 | 7 | 22 | 5 | 14 |
| 23 | 2 | 53 | 0 | 54 | 11 | 12 | 9 | 16 | 7 | 18 | 5 | 10 |
| 24 | 2 | 49 | 0 | 50 | 11 | 8 | 9 | 12 | 7 | 14 | 5 | 6 |
| 25 | 2 | 45 | 0 | 47 | 11 | 5 | 9 | 9 | 7 | 10 | 5 | 0 |
| 26 | 2 | 41 | 0 | 43 | 11 | 1 | 9 | 5 | 7 | 6 | 4 | 58 |
| 27 | 2 | 37 | 0 | 39 | 10 | 57 | 9 | 1 | 7 | 2 | 4 | 54 |
| 28 | 2 | 33 | 0 | 35 | 10 | 54 | 8 | 57 | 6 | 58 | 4 | 50 |
| 29 | 2 | 29 | | | 10 | 50 | 8 | 53 | 6 | 54 | 4 | 46 |
| 30 | 2 | 25 | | | 10 | 46 | 8 | 50 | 6 | 49 | 4 | 41 |
| 31 | 2 | 22 | | | 10 | 43 | | | 6 | 45 | | |

Days

| Days | July h. | July m. | August h. | August m. | Septemb. h. | Septemb. m. | October h. | October m. | Nov. h. | Nov. m. | Decem h. | Decem m. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 4 | 37 | 2 | 35 | 0 | 41 | 10 | 52 | 8 | 53 | 6 | 45 |
| 2 | 4 | 33 | 2 | 31 | 0 | 37 | 10 | 48 | 8 | 49 | 6 | 40 |
| 3 | 4 | 29 | 2 | 27 | 0 | 34 | 10 | 45 | 8 | 45 | 6 | 35 |
| 4 | 4 | 25 | 2 | 23 | 0 | 30 | 10 | 41 | 8 | 41 | 6 | 31 |
| 5 | 4 | 21 | 2 | 20 | 0 | 27 | 10 | 38 | 8 | 38 | 6 | 26 |
| 6 | 4 | 17 | 2 | 16 | 0 | 23 | 10 | 34 | 8 | 33 | 6 | 22 |
| 7 | 4 | 13 | 2 | 12 | 0 | 19 | 10 | 30 | 8 | 29 | 6 | 18 |
| 8 | 4 | 9 | 2 | 9 | 0 | 16 | 10 | 26 | 8 | 24 | 6 | 13 |
| 9 | 4 | 5 | 2 | 5 | 0 | 12 | 10 | 22 | 8 | 20 | 6 | 9 |
| 10 | 4 | 1 | 2 | 2 | 0 | 9 | 10 | 19 | 8 | 15 | 6 | 4 |
| 11 | 3 | 57 | 1 | 59 | 0 | 5 | 10 | 15 | 8 | 11 | 6 | 0 |
| 12 | 3 | 53 | 1 | 54 | 0 | 1 | 10 | 11 | 8 | 7 | 5 | 55 |
| 13 | 3 | 49 | 1 | 50 | 11 | 58 | 10 | 7 | 8 | 2 | 5 | 51 |
| 14 | 3 | 45 | 1 | 46 | 11 | 54 | 10 | 3 | 7 | 58 | 5 | 46 |
| 15 | 3 | 41 | 1 | 43 | 11 | 51 | 10 | 0 | 7 | 53 | 5 | 41 |
| 16 | 3 | 37 | 1 | 39 | 11 | 47 | 9 | 56 | 7 | 49 | 5 | 36 |
| 17 | 3 | 33 | 1 | 35 | 11 | 43 | 9 | 52 | 7 | 45 | 5 | 32 |
| 18 | 3 | 29 | 1 | 32 | 11 | 40 | 9 | 48 | 7 | 41 | 5 | 27 |
| 19 | 3 | 25 | 1 | 28 | 11 | 36 | 9 | 44 | 7 | 37 | 5 | 23 |
| 20 | 3 | 21 | 1 | 25 | 11 | 33 | 9 | 40 | 7 | 32 | 5 | 19 |
| 21 | 3 | 17 | 1 | 21 | 11 | 29 | 9 | 36 | 7 | 28 | 5 | 15 |
| 22 | 3 | 13 | 1 | 17 | 11 | 25 | 9 | 32 | 7 | 24 | 5 | 11 |
| 23 | 3 | 9 | 1 | 14 | 11 | 22 | 9 | 28 | 7 | 20 | 5 | 6 |
| 24 | 3 | 5 | 1 | 10 | 11 | 18 | 9 | 24 | 7 | 15 | 5 | 2 |
| 25 | 3 | 2 | 1 | 7 | 11 | 15 | 9 | 21 | 7 | 11 | 4 | 57 |
| 26 | 2 | 53 | 1 | 3 | 11 | 11 | 9 | 17 | 7 | 7 | 4 | 53 |
| 27 | 2 | 54 | 0 | 58 | 11 | 7 | 9 | 13 | 7 | 3 | 4 | 49 |
| 28 | 2 | 50 | 0 | 56 | 11 | 3 | 9 | 9 | 6 | 58 | 4 | 44 |
| 29 | 2 | 46 | 0 | 52 | 10 | 59 | 9 | 5 | 6 | 54 | 4 | 40 |
| 30 | 2 | 42 | 0 | 49 | 10 | 56 | 9 | 1 | 6 | 49 | 4 | 35 |
| 31 | 2 | 39 | 0 | 45 | | | 8 | 57 | | | 4 | 30 |

A Table of the Right Ascension of 46 Eminent Fixed Stars throughout the *Zodiack*.

| The Names of the STARS. | R. Ascen. H. | M. |
|---|---|---|
| South Star in the Whale's Tail | 0 | 27 |
| The Girdle of *Andromeda* | 0 | 51 |
| The formost Horn of the Ram | 1 | 36 |
| Whales Belly | 1 | 46 |
| *South* Foot of *Andromeda* | 1 | 43 |
| The Whales Jaw | 2 | 45 |
| The Brightest of the Seven Stars | 3 | 28 |
| *Aldebaron*, or the Bull's Eye | 4 | 17 |
| *Capella*, or the Goat | 4 | 52 |
| Formost Shoulder of *Orion* | 5 | 8 |
| *Orion's* Head | 5 | 17 |
| Middlemost in *Orion's* Belt | 5 | 20 |
| *Cyrius*, or the Great Dog | 6 | 30 |
| *Procion*, or the Lesser Dog | 7 | 22 |
| The Lowermost Head of the Twins | 7 | 26 |
| *North Ascellus* | 8 | 23 |
| *South Ascellus* | 8 | 25 |
| *Cor Leonis*, or the Lyon's Heart | 9 | 50 |
| *Cauda Leonis*, or the Lyon's Tail | 11 | 32 |
| *Vindemiatrix* | 0 | 46 |
| *Spica Virginis* | 1 | 8 |
| *Arcturus* | 2 | 1 |
| Left Shoulder of *Bootès* | 2 | 19 |
| *South* Ballance | 2 | 23 |
| *North* Ballance | 3 | 3 |
| Bright Star of the Crown | 3 | 25 |
| *Antares*, or the *Scorpion's* Heart | 4 | 9 |
| *Hercules* Right Shoulder | 4 | 11 |
| *Hercules* Head | 5 | 0 |
| Head of *Ophyncus* | 5 | 20 |
| *Lyra*, or the Harp | 6 | 22 |
| *Vultures* Tail | 6 | 51 |
| The Swan's Bill | 7 | 18 |
| The Vulture | 7 | 35 |
| Lowermost Horn of the Goat | 8 | 30 |
| Swan's Breast | 8 | 11 |
| Swan's Tail | 8 | 31 |
| Lowermost Wing of the Swan | 8 | 33 |
| Girdle of *Cepheus* | 9 | 25 |
| *Pegasus* Mouth | 9 | 28 |
| Right Shoulder of the Water-bearer | 9 | 47 |
| *Fomahaunt* | 10 | 39 |
| *Scheat* | 10 | 48 |
| *Mercha* | 10 | 49 |
| Head of *Andromeda* | 11 | 32 |
| *Cassiopea's* Chair | 11 | 53 |

V. *To find the* Hour *of the* Night *by the* Stars.

*Example.*

OBserving by fome of the ways before prefcribed, that upon the laft Day of *December*, I found that the *Great Dog*'s Horary diftance from *the Meridian* was 9 Hours, 22 Minutes; which fet down as followeth:——Then (by the Firft *Table*) I find the Complement of *the Sun*'s *R. Afcenfion* on the 31*ft* of *December*, to be 4 Hours 30 Minutes; which fet down under the former------And (by the Second *Table*) I find *the R. Afcenfion* of *the Great Dog* to be 6 Hours, 30 Minutes; which fet down under the Two former: All which being added together, do make 20 Hours, 22 Minutes. Which (becaufe it is above 12 Hours) fubftract 12 Hours from the Sum, the Remainder will be 8 Hours, 22 Minutes for the true Hour of the Night.

| | H. | M. |
|---|---|---|
| The *Great Dog's* Hour | 9 | 22 |
| The Comp. of the *Sun*'s R.Afcenfion, *December* 31 | 4 | 30 |
| The *Great Dog*'s R. Afcenfion | 6 | 30 |
| The Sum | 20 | 22 |
| Subftract | 12 | 00 |
| There Remains | 8 | 22 |

For the true Hour of the Night.

VI. *Another way to find the* Hour *of the* Night, *by feeing any* Star *upon the* Meridian.

I have already intimated, how you map know by *the Dial* upon a Poft before mentioned, what *Stars* are upon *the Meridian* at any time of *the Night*; It refteth now to fhew how (from thence) to find *the Hour* of *the Night*.

*Example.*

Suppofe, therefore, that upon the 20*th* Day of *January*, I find *Aldebaron*, or *the Bull's Eye*, to be upon *the South* part of *the Meridian*, then (by the Firft *Table*) I find the Complement of the *Sun's R. Afcenfion* on the 20*th* of *January*, to be 3 hours, 6 minutes-----And (by the Second *Table*) *the R. Afcenfion* of *the Bull's Eye* (or *Aldebaron*) to be 4 hours, 17 minutes. Thefe Two added together make 7 hours, 23 minutes, for the true Hour of the Night.

| | h. | m. |
|---|---|---|
| The Comp. of *the Sun's R. Afcen.* Jan. 2 | 3 | 6 |
| The R. *Afcenfion* of *the Bull's Eye* | 4 | 17 |
| Their Sum | 7 | 23 |

Which is the true *Hour* of the Night, *Jan.* 20.

## CONCLUSION.

THere are ſeveral other ways to find the Hour of the Day or Night, by the *Sun*, *Moon*, or *Stars*; as by *Quadrants*, *Rings*, *Cylinders*, *Walking Staves*, *Nocturnals* of ſeveral Kinds: By the Shadow of the Moon upon a Sun-Dial, and many other ways. But foraſmuch as theſe Inſtruments are to be had at any Shop where *Mathematical Inſtruments* are Made, or Sold, I ſhall forbear to ſay any thing of them in this place: Only I ſhall exhibit to the Practitioners View, Two Tables, by help of which the Uſual Furniture may be put into all ſorts of Sun-Dials, *Plain*, *Concave*, *Convex*, *Regular* or *Irregular*. And alſo all the forementioned *Quadrants*, *Rings*, and other *Inſtruments*, which ſhew *the Hour* and *Azimuth* of the Sun by *the Altitude* thereof, are made.

A Table shewing the *Altitude* of the Sun for every Hour and Quarter, at his Entrance into every of the XII Signs of the *Zodiack*, in the Latitude of *London*, 51 deg. 32 min.

| Hours | ♋ Altit. D. M. | ♊ ♌ Altit. D. M. | ♉ ♍ Altit. D. M. | ♈ ♎ Altit. D. M. | ♓ ♏ Altit. D. M. | ♒ ♐ Altit. D. M. | ♑ Altit. D. M. |
|---|---|---|---|---|---|---|---|
| XII | 61 59 | 58 41 | 49 59 | 38 28 | 26 57 | 18 15 | 14 57 |
| 1 | 61 49 | 58 34 | 49 52 | 38 22 | 26 52 | 18 10 | 14 52 |
| 2 | 61 23 | 58 8 | 49 32 | 38 4 | 26 37 | 17 56 | 14 39 |
| 3 | 60 40 | 57 27 | 48 57 | 37 36 | 26 12 | 17 34 | 14 18 |
| I XI | 59 42 | 56 33 | 48 10 | 36 56 | 25 37 | 17 3 | 13 48 |
| 1 | 58 29 | 55 25 | 47 11 | 36 5 | 24 53 | 16 24 | 13 9 |
| 2 | 57 4 | 54 6 | 46 1 | 35 4 | 24 1 | 15 36 | 12 23 |
| 3 | 55 29 | 52 34 | 44 40 | 33 55 | 22 59 | 14 19 | 11 29 |
| II X | 53 45 | 50 55 | 43 11 | 32 36 | 21 49 | 13 36 | 10 28 |
| 1 | 51 53 | 49 7 | 41 52 | 31 8 | 20 31 | 12 24 | 9 19 |
| 2 | 49 54 | 47 12 | 39 47 | 29 34 | 19 6 | 11 6 | 8 3 |
| 3 | 47 51 | 45 13 | 37 57 | 27 53 | 17 36 | 9 42 | 6 41 |
| III VIII | 45 42 | 43 7 | 35 59 | 26 5 | 15 57 | 8 11 | 5 13 |
| 1 | 43 31 | 40 58 | 33 57 | 24 12 | 14 13 | 6 34 | 3 39 |
| 2 | 41 15 | 38 45 | 31 49 | 2 25 | 12 23 | 4 51 | 1 59 |
| 3 | 38 59 | 36 30 | 29 40 | 20 13 | 10 30 | 3 5 | 0 15 |
| IV VII | 36 42 | 34 14 | 27 28 | 18 7 | 8 32 | 1 13 | |
| 1 | 34 23 | 31 56 | 25 13 | 15 58 | 6 31 | | |
| 2 | 32 4 | 29 37 | 22 56 | 13 46 | 4 25 | | |
| 3 | 29 43 | 27 16 | 20 37 | 11 32 | 2 16 | | |
| V VII | 27 23 | 24 56 | 18 18 | 9 17 | 0 5 | | |
| 1 | 25 4 | 22 37 | 15 59 | 6 58 | | | |
| 2 | 22 46 | 20 17 | 13 39 | 4 39 | | | |
| 3 | 20 28 | 17 57 | 11 19 | 2 20 | | | |
| VI VI | 18 12 | 15 42 | 9 0 | | | | |
| 1 | 15 58 | 14 0 | 6 44 | | | | |
| 2 | 13 46 | 11 13 | 4 22 | | | | |
| 3 | 11 37 | 9 1 | 2 8 | | | | |
| VII V | 9 30 | 6 52 | | | | | |
| 1 | 7 25 | 4 46 | | | | | |
| 2 | 5 24 | 2 42 | | | | | |
| 3 | 3 27 | 0 43 | | | | | |
| VIII IV | 1 34 | | | | | | |

A

A Table of the Sun's *Azimuth* from the *South* for every Hour and Quarter, at his Entrance into every of the XII Signs of the *Zodiack* in the Latitude of *London* 51 deg. 32 min.

| Hours | ♋ | | ♊ ♌ | | ♉ ♍ | | ♈ ♎ | | ♓ ♏ | | ♒ ♐ | | ♑ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Azim.* | | *Azim.* | | *Azim.* | | *Azim.* | | *Azim.* | | *Azim.* | | *Azim.* | |
| | D. | M. | D. | M. | D. | M. | D. | M. | D. | M. | D. | M. | D. | M. |
| XII | 00 | 0 | 00 | 0 | 00 | 0 | 00 | 0 | 00 | 0 | 00 | 0 | 00 | 0 |
| 1 | 7 | 10 | 5 | 53 | 5 | 37 | 4 | 55 | 3 | 54 | 3 | 53 | 3 | 52 |
| 2 | 14 | 22 | 13 | 24 | 11 | 10 | 9 | 40 | 7 | 57 | 7 | 40 | 7 | 10 |
| 3 | 21 | 27 | 19 | 53 | 16 | 44 | 14 | 13 | 12 | 11 | 11 | 10 | 10 | 37 |
| I XI | 27 | 56 | 26 | 0 | 22 | 13 | 18 | 52 | 16 | 22 | 14 | 45 | 14 | 13 |
| 1 | 34 | 14 | 32 | 1 | 27 | 32 | 23 | 22 | 20 | 15 | 18 | 17 | 17 | 38 |
| 2 | 40 | 12 | 37 | 40 | 32 | 41 | 27 | 41 | 24 | 6 | 21 | 53 | 20 | 59 |
| 3 | 45 | 39 | 43 | 4 | 37 | 32 | 32 | 8 | 29 | 44 | 26 | 30 | 24 | 25 |
| II X | 50 | 51 | 47 | 57 | 42 | 5 | 36 | 24 | 31 | 50 | 28 | 52 | 27 | 49 |
| 1 | 55 | 31 | 52 | 41 | 47 | 4 | 40 | 30 | 35 | 35 | 32 | 18 | 31 | 0 |
| 2 | 51 | 43 | 57 | 11 | 50 | 51 | 44 | 26 | 39 | 10 | 35 | 39 | 34 | 17 |
| 3 | 64 | 11 | 61 | 18 | 54 | 33 | 48 | 13 | 42 | 36 | 48 | 50 | 37 | 34 |
| III IX | 68 | 10 | 65 | 16 | 58 | 47 | 51 | 56 | 46 | 2 | 42 | 4 | 40 | 38 |
| 1 | 71 | 52 | 69 | 56 | 62 | 33 | 55 | 33 | 49 | 25 | 45 | 16 | 43 | 40 |
| 2 | 75 | 26 | 72 | 37 | 66 | 10 | 58 | 59 | 52 | 43 | 48 | 21 | 46 | 42 |
| 3 | 78 | 48 | 76 | 5 | 69 | 23 | 62 | 22 | 55 | 59 | 51 | 22 | 49 | 40 |
| IV VIII | 82 | 0 | 79 | 20 | 72 | 57 | 65 | 40 | 59 | 0 | 54 | 22 | | |
| 1 | 85 | 8 | 82 | 42 | 76 | 12 | 68 | 53 | 62 | 8 | | | | |
| 2 | 88 | 10 | 85 | 38 | 79 | 23 | 72 | 6 | 65 | 12 | | | | |
| 3 | 91 | 9 | 87 | 50 | 82 | 28 | 75 | 7 | 68 | 12 | | | | |
| V VII | 94 | 15 | 91 | 34 | 85 | 30 | 78 | 6 | 71 | 10 | | | | |
| 1 | 96 | 51 | 94 | 25 | 88 | 27 | 81 | 9 | | | | | | |
| 2 | 99 | 38 | 97 | 16 | 91 | 23 | 84 | 6 | | | | | | |
| 3 | 102 | 25 | 100 | 7 | 94 | 22 | 87 | 4 | | | | | | |
| VI VI | 105 | 8 | 102 | 54 | 97 | 12 | | | | | | | | |
| 1 | 107 | 22 | 104 | 58 | 100 | 2 | | | | | | | | |
| 2 | 110 | 36 | 108 | 26 | 103 | 0 | | | | | | | | |
| 3 | 113 | 88 | 111 | 14 | 105 | 54 | | | | | | | | |
| VII V | 116 | 3 | 114 | 3 | | | | | | | | | | |
| 1 | 118 | 50 | 116 | 54 | | | | | | | | | | |
| 2 | 121 | 41 | 119 | 47 | | | | | | | | | | |
| 3 | 124 | 29 | 122 | 37 | | | | | | | | | | |
| VIII IV | 127 | 24 | | | | | | | | | | | | |



An

## *An Easie Way to make a* Spot-Dial *within a Room, without any Calculation, or Use of Threads,* &c.

THis may be done Two Ways, either 1. By the direct Rays of the Sun thorough a little Hole in the Glaſs: Or, 2. By the Reflected Rays from a ſmall ſhow of a *Looking-Glaſs*, ſet in a convenient place in the Window. The firſt way I account not ſo convenient, becauſe the Hour-Lines will many of them fall on the Floor, Tables, *&c.*

The other way is this, 1. Take a little piece of *Looking-Glaſs* (common Glaſs may ſerve, but not ſo well) about the breadth of a ſixpence, faſten this ſo in the bottom of the Window (or ſides if you ſee good) that the Rays of the *Sun* may not be hindred from coming upon it (or as little as may be).

2. It is neceſſary that you have with you, upon this occaſion, a rightly ſet Sun Dial Quadrant, *&c.* The like to find the ſeveral hours of the Day by being ſo provided, upon a clear Sun-ſhine Day, watch the Sun-Dial till the ſhadow is juſt upon ſome Hour-Line, then immediately obſerve where your ſpot of light falls on the Wall or Ceiling; and there with black Lead, or the like, make a mark, and alſo ſet a Figure by it of what hour it is. Do the ſame by the next hour, and ſo on as long as the *Sun* ſhines, ſo as to give a ſpot in the room.

3. About a Month or more after, obſerve in like manner by your *Sun Dial* where the ſpot falls on the Wall or Ceiling at the ſeveral hours, and make marks and figures as you did before, and you will find the hour ſpots now to fall far diſtant from where they were a Month ago.

4. This done with a long Ruler and black Lead, Ink, or the like, draw a long line joyning each pair of marks that have the ſame figure annexed to them, and each ſuch line produced at both ends ſhall be the hour line for that hour; to which put, where you ſee fit, its proper figures, and in like manner do by the reſt.

*Note*, 1. The beſt time of the year for the Operation is the *Spring*, or *Autumn*; other times of the year may ſerve, ſo as the times of obſervations be either ***both before***, or ***both after the ſolſtizes***, ***June*** **11**, ***December*** **11.**

*Note* 2. When an hour-line drawn upon the Ceiling comes to the Wall, there will be then needful a third obſervation where the ſpot falls on the Wall at that Hour; at which having made a mark, draw a ſtraight line from the end of the line on the Ceiling, down to your mark, for that hour on the Wall; ſo will you have that hour-line compleat. In like manner you may do by the reſt if there be need.

*Note*, 3. Your Glaſs, and what it ſtands on muſt be very firm; for if it be moved ever ſo little, 'twill not agree with your hour-lines.

They who pleaſe and have a convenient Room and Window, may by the very ſame method draw hour-lines to a ſpot of light coming throw a little hole in a Quarry of Glaſs, but then it will be convenient that the reſt of the Quarry be darkned by paſting a piece of black paper, or the like, on the inner ſide, leaving the hole in the middle.

FINIS.

# RECREATIONS Cryptographical.

THIS *Cryptographical Art* is of great uſe in many reſpects, but principally in *War*. And if we conſider to what neceſſities great Princes and Potentates have been put unto to communicate their Minds or Intentions to their Correſpondents before the improvement of this Art, it would make a man but of a reaſonable underſtanding admire: Wherefore I ſhall here give you a very brief account of ſome of them, and afterwards ſhew ſome other more Artificial and abſolute ways whereby Communication may be had both ſecretly and ſwiftly.

## I. *Of ſome Antient ways.*

1. When *Hiſtæus* the *Mileſian* was kept Priſoner by *Darius*, and deſpairing of his return home, unleſs he could find out ſome way to ſend to *Ariſtagoras* (who was his Subſtitute at *Miletum*) to perſwade his Revolt from *Darius*, but knowing that all Paſſages were ſtopt, and all Meſſengers ſtrictly examined and ſearched; he at length found out this (both tedious and weak) courſe. He got a truſty Servant of his, the Hair of whoſe Head he cauſed to be ſhaved off, and then upon his bald Pate he writes his mind to *Ariſtagoras*, keeping his Servant privately about him till his Hair was ſomewhat grown, and then bad him haſte to *Ariſtagoras*, and bad him cauſe him to be ſhaven again, and then upon his Head he ſhould find what his Lord had writ unto him.

2. When *Harpagus* had a mind that *Cyrus* ſhould haſten his Invaſion on *Media* (*Cyrus* being then in *Perſia*,) his Letter he ſent to him he incloſed in the belly of a Hare.

3. The *Lacedemonians* uſed this way to communicate their Letters to their Generals abroad, which in caſe of Interception, the Contents ſhould not be diſcovered. They had made two round Sticks or Cylinders of the ſame length and thickneſs, one of which was delivered to the General when he ſet forth, and the other was kept at home by the chief *Magiſtrate*. When occaſion was, they wound about the Stick a long narrow ſcrowl of Paper or Parchment, in ſuch manner, like the threads of a Screw, ſo that the edges of the Paper or Parchment ſhould always lie cloſe together; the Paper thus fitted to the Stick (or Cylinder) they wrote their Letters upon the tranſverſe junctures of the Paper, ſo that one

one part of each Word or Letter was in one place, and the other in an other: When they had finished their Writing, they took off the scroll and sent it to the General, who knew how to apply it; and if it had been intercepted, the Enemy could make nothing of it; and this manner of Writing they called *Scytale*.

4. The *Milesians* used to Write their Letters, and inclose them in a Cake, or Loaf of Bread.

5. The *Romans* into the hilt or scabord of a Sword.

6. The *Persians* used to fix them to Arrows, and shoot them to places appointed near hand.

7. *Torosthanes* by a Pigeon, stained with Purple, gave notice of his Victory at the Olympick Games, to his Father in *Ægina*, the same day that he obtained it. And this way of conveyance by Pigeons at great distances is of wonderful Celerity: For in *Aleppo* they have Pigeons which will fly (with Letters fixed to their Legs, or about their Necks) from *Babylon* to *Aleppo* in 48 hours, which is accounted 30 days journey. The manner of tutering their Pigeons is this: They take them when they sit on their Nests, transporting them in open Cages, and return them with Letters; who will never give rest to their Wings until they come to their Young. But let this suffice for some of the ways used by the Antients, I will proceed now to more Artificial ways of effecting the same.

## I. *By the 24 Common Letters of the Alphabet.*

THE *Letters* of the *Alphabet*, by which you would represent your Mind to your *Correspondent*, may be so disposed in the form of a Right Angled *Parallelogram* (with any Number of *Cyphers*, *Intervals*, or (rather) *superfluous Letters* between every *significant Letter*;) so that *the Writing* may be read by your Correspondent any of these ways, which of them shall be agreed upon between you; As,

| | | | As in Example. |
|---|---|---|---|
| 1 | In upright Columns | Descending with 4 intervals. | I |
| 2 | | Ascending with 3 intervals. | II. |
| 3 | | Descending and Ascending alternately 2 inter. | III |
| 4 | | Ascending and Descending alternately 5 inter. | IV |
| | | Or, | |
| 5 | Horizontally in Lines | Direct with 7 intervals. | V |
| 6 | | Retrograde 5 intervals. | VI |
| 7 | | Direct and Retrograde alternately 2 Inter. | VII |
| 8 | | Retrograde and direct alternately 3 inter. | VIII |

### *Example* I.

Suppose that I would write to my Correspondent these Words,

**Your Uncle is now Dead.**

Wherefore I write it in *Upright Columns* descending, with 4 *Intervals*: (Which my Correspondent is supposed to know:) Wherefore I first make 4 Pricks, one under another, and under them I make the first Letter of my intended Writing [*y*], under that four Pricks more, and under them the next Letter [*o*], then two Pricks under, and (because your Column will hold no more Pricks below) two above in the next Column, and under them [*u*]; *&c.* As in the *Parallelogram* following.

Points

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| . | . | u | . | . | . | . | a | s | r | U | s | a | k | t | a |
| . | . | . | . | i | . | . | . | g | g | b | i | i | r | r | s |
| . | u | . | . | . | . | d | . | b | u | r | d | b | l | d | t |
| . | . | . | l | . | . | . | . | c | l | y | l | d | m | m | a |
| y | . | . | . | . | o | . | . | y | o | x | o | c | o | s | l |
| . | . | n | . | . | . | . | d | l | m | n | q | f | q | g | d |
| . | . | . | . | s | . | . | &c | f | y | t | s | s | r | y | &c |
| . | r | . | . | . | . | e | . | t | r | p | b | e | g | e | m |
| . | . | . | e | . | . | . | . | ſ | g | o | e | g | b | p | o |
| o | . | . | . | . | w | . | . | o | q | g | m | i | w | l | n |
| . | . | c | . | . | . | . | . | m | o | c | y | h | l | g | t |
| . | . | . | . | n | . | . | . | b | l | m | t | n | s | q | v |
| Points made for the Intervals. | | | | | | | | Superfluous Letters to ſupply the Intervals. | | | | | | | |

I have been ſomewhat large in this, but it is becauſe I will give *Examples* in all the reſt, but not in a double Nature, as I have done here, with Points only to ſupply the ſuperfluous Letters.

### *Example* II.

**Haſte from London, for you are betrayed.**

Upright Columns Aſcending, with 3 Intervals.

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| . | . | . | o | . | . | . | a | . | . | . | . |
| . | . | o | . | . | . | y | . | . | . | y | . |
| . | e | . | . | . | f | . | . | . | t | . | . |
| a | . | . | . | d | . | . | . | e | . | . | &c |
| . | . | . | L | . | . | . | u | . | . | . | d |
| . | . | r | . | . | . | r | . | . | . | a | . |
| . | t | . | . | . | n | . | . | . | e | . | . |
| h | . | . | . | n | . | . | . | r | . | . | . |
| . | . | . | m | . | . | . | o | . | . | . | e |
| . | . | f | . | . | . | o | . | . | . | r | . |
| . | s | . | . | . | o | . | . | . | b | . | . |

*Example* III.

**Your Castle will this Night be Surrendred to the Enemy by your own Souldiers.**

Deſcending and Aſcending Alternately, with 2 Intervals.

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| . | t | . | i | . | e | . | r | . | e | . | o | . | u | . | . |
| . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| y | . | l | . | s | . | ſ | . | e | . | n | . | u | . | l | . |
| . | ſ | . | h | . | b | . | d | . | e | . | y | . | o | . | . |
| . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| o | . | e | . | n | . | u | . | d | . | e | . | r | . | d | &c |
| . | a | . | t | . | t | . | n | . | h | . | y | . | ſ | . | s |
| . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| u | . | w | . | i | . | r | . | t | . | m | . | o | . | i | . |
| . | c | . | l | . | h | . | e | . | t | . | b | . | n | . | r |
| . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| r | . | i | . | g | . | r | . | o | . | y | . | w | . | e | . |

*Example* IV.

**The Blow is given by Tom.**

Aſcending and Deſcending alternately, with five Intervals.

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| . | . | . | . | . | ) | . | . | . | . | . | e | . | . | . | . | . |
| T | . | . | . | . | . | i | . | . | . | . | . | b | . | . | . | . |
| . | . | . | B | . | . | . | . | . | i | . | . | . | . | . | o | . |
| . | . | e | . | . | . | . | . | g | . | . | . | . | . | T | . | . |
| . | h | . | . | . | . | . | s | . | . | . | . | . | y | . | . | &c |
| . | . | . | . | l | . | . | . | . | . | v | . | . | . | . | . | m |
| . | . | . | . | . | w | . | . | . | . | . | n | . | . | . | . | . |

Example

*Example* V.
**Our Provision is at an end.**

Horizontal direct, with ſeven Intervals.

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| . | . | . | . | . | . | . | O | . | . | . | . | . | . | . | u | . | . | . | . | . | . |
| . | r | . | . | . | . | . | . | . | P | . | . | . | . | . | . | . | r | . | . | . | . |
| . | . | . | o | . | . | . | . | . | . | . | v | . | . | . | . | . | . | . | i | . | . |
| . | . | . | . | . | s | . | . | . | . | . | . | . | i | . | . | . | . | . | . | . | o |
| . | . | . | . | . | . | . | n | . | . | . | . | . | . | . | i | . | . | . | . | . | . |
| . | s | . | . | . | . | . | . | . | a | . | . | . | . | . | . | . | t | . | . | . | . |
| . | . | . | a | . | . | . | . | . | . | . | n | . | . | . | . | . | . | . | e | . | . |
| . | . | . | . | . | n | . | - | . | . | . | . | . | d | &c | . | . | . | . | . | . | . |

*Example* VI.
**If we are not Relieved this Day, we muſt Surrender.**

Horizontal, but Retrograde, with 5 Intervals.

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| . | . | . | w | . | . | . | . | . | f | . | . | . | . | . | I | . | . | . | . | . |
| e | . | . | . | . | . | r | . | . | . | . | . | a | . | . | . | . | . | e | . | . |
| . | . | . | t | . | . | . | . | . | o | . | . | . | . | . | n | . | . | . | . | . |
| i | . | . | . | . | . | l | . | . | . | . | . | e | . | . | . | . | . | R | . | . |
| . | . | . | e | . | . | . | . | . | v | . | . | . | . | . | e | . | . | . | . | . |
| i | . | . | . | . | . | h | . | . | . | . | . | t | . | . | . | . | . | d | . | . |
| . | . | . | a | . | . | . | . | . | d | . | . | . | . | . | s | . | . | . | . | . |
| m | . | . | . | . | . | e | . | . | . | . | . | w | . | . | . | . | . | y | . | . |
| . | . | . | t | . | . | . | . | . | ſ | . | . | . | . | . | u | . | . | . | . | . |
| r | . | . | . | . | . | r | . | . | . | . | . | u | . | . | . | . | . | S | . | . |
| . | . | . | d | . | . | . | . | . | n | . | . | . | . | . | e | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | &c | r | . | . | . | . | . | e | . | . |

*Example* VII.
**Our Victuals and Amunition are both at an end.**

Direct and Retrograde alternately, 2 Intervals.

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| . | . | O | . | . | u | . | . | r | . | . | V | . | . | i | . | . | c | . | . |
| . | n | . | . | a | . | . | s | . | . | l | . | . | a | . | . | u | . | . | t |
| . | d | . | . | A | . | . | m | . | . | u | . | . | n | . | . | i | . | . | t |
| . | . | e | . | . | r | . | . | a | . | . | n | . | . | o | . | . | i | . | . |
| b | . | . | o | . | . | t | . | . | h | . | . | a | . | . | t | . | . | [illegible] | . |
| . | . | . | . | . | . | . | . | &c | d | . | . | n | . | . | [illegible] | . | . | n | . |

*Example* VIII.
**Your Brother James hath betrayed you.**

Horizontal, Retrograde and Direct, alternately, with 3 Intervals.

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| . | . | . | u | . | . | . | o | . | . | . | Y | . | . | . |
| r | . | . | . | B | . | . | . | r | . | . | . | o | . | . |
| . | r | . | . | . | e | . | . | . | h | . | . | . | t | . |
| . | . | J | . | . | . | a | . | . | . | m | . | . | . | e |
| . | . | . | a | . | . | . | h | . | . | . | s | . | . | . |
| t | . | . | . | h | . | . | . | b | . | . | . | e | . | . |
| . | y | . | . | . | a | . | . | . | r | . | . | . | t | . |
| . | . | e | . | . | . | d | . | . | . | y | . | . | . | o |
| . | . | . | . | . | . | . | . | . | . | &c | u | . | . | . |

In all these ways may *secret Writing* be written and read in a *Parallelogram :* But *the Figure* may be any other, as a *Triangle*, *Rhombus*, &c. and to be read *Diagonally*, either *Ascending* or *Descending*, or both *alternately* ; as in *these Figures* following.

*Example*

*Example* IX.
Fly For the Town will be fired in three places.

In a Triangle *Diagonally* Aſcending, with 2 Intervals.

```
                    r
                  . w
                 .  .
              o  .  l
               . o  .
             .  .  .  .
            f  .  l  i
           :  T  .  .  i
          .  .  .  .  .
         y  .  i  f  .  p
          .  e  .  :  d  .
       .  .  .  .  .  .  .
      l  :  w  e  .  3  a
       .  h  .  .  e  .  .  .
     .  .  .  .  .  .  e
    F  .  n  b  .  n  l  .  .
   .  t  .  :  r  .  .  .  .
  .  .  .  .  .  .  .  c  s  o
                    .  .  ⊙  *
```

## II. *By* Tranſpoſing *of the* Letters *of the* Alphabet.

JUlius Cæſar, when he communicated his mind to his *Correſpondent* (to whom he had before declared his *manner of Writing,*) he did it by this way of *Tranſpoſition*, putting D, the *fourth Letter*, for *A*, the *first Letter of the Alphabet*; and ſo throughout *the whole Alphabet*, as in this *Scheme*, which will ſerve for a *Clavis* to unlock *ſecret Matter* written according to *this Tranſpoſition*, which may be varied Millions of ways.

*The Scheme, or Clavis.*

| a | b | c | d | e | f | g | h | i | k | l | m | n | o | p | q | r | ſ | t | v | w | x | y | z |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| - | - | - | - | - | - | - | - | -- | - | - | -- | - | - | - | - | - | -- | - | - | -- | - | - | - |
| d | e | f | g | h | i | k | l | m | n | o | p | q | r | s | t | u | w | x | y | z | a | b | c |

The *Scheme* thus prepared, and *the Correſpondent* knowing *the Order of Tranſpoſition*, Suppoſe that I would write theſe words; To be read in Upright Columbs Deſcending:

As you tender your own safety get out of Italy, and repair to Paris with what speed you can.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| D | g | z | k | M | v | S | l | b |
| w | h | q | h | x | h | d | z | g |
| b | v | w | x | d | s | v | l | b |
| r | b | d | r | o | d | m | d | r |
| y | r | i | y | b | m | w | x | y |
| x | y | h | x | d | v | z | w | f |
| h | v | x | r | q | x | m | s | d |
| q | r | b | i | g | r | x | h | q |

Now by this *Clavis* (or any other *Transposition* (or varying) of the *Letters of the Alphabet*) you may frame your *Writing* to be read any of the former ways, as *Downwards*, *Upwards*, *Direct*, *Retrograde*, *Diagonal*, &c.

*But this way (in my judgment) for Secrecy, is more liable to be discovered (if intercepted) than the former ways, by supplying Intervals by (any number of) superfluous* Letters; *for that in this way there are no more Letters used than will be required to make out the* Words *intended; which makes it very liable to discovery: VVherefore I shall in the next place shew a way whereby to use other* Characters *instead of the* Letters *of the* Alphabet; *with Intervals of a different Character interposed.*

## III. *By* Other Characters, *which shall Represent the* 24 Letters *of the Alphabet.*

NOT to invent *new*, *strange*, and *insignificant Characters*, such as your *Steniographers*, or *Short-Hand Writers* use; I shall here present you with an *Alphabet* of known *Characters*; *viz.* with those of *the Astronomical Signs*, *Planets* and *Aspects*; Whereof *the Twelve Signs*, *the Seven Planets*, and *the Five Aspects* together makes Twenty Four, equal to the Number of *the Letters of the Alphabet*. And of these let *the five Aspects* represent *the five Vowels*, {a e i o u / ☌ ☍ □ △ ⚹} And let *the Characters* of *the Seven Planets* represent *the Letters* towards the beginning of the *Alphabet*: And the Characters of the 12 *Signs* the *Letters* towards the end of *the Alphabet*; as in the following *Scheme*, or *Astronomical Clavis*.

### *The Astronomical Clavis.*

| a | b | c | d | e | f | g | h | i | k | l | m | n | o | p | q | r | s | t | u | w | x | y | z |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ☌ | ♄ | ♃ | ♂ | ☍ | ☉ | ♀ | ☿ | □ | ☾ | ♈ | ♉ | ♊ | △ | ♋ | ♌ | ♍ | ♎ | ♏ | ⚹ | ♐ | ♑ | ♒ | ♓ |

The *Key* being thus agreed upon between you and your Correspondent, it will be very easie to communicate your mind to him in any of the forementioned Methods, *viz.* by *Parallelogram*, *Triangle*, &c.

And

And so supposing you would write to your *Correspondent*, to be read in a *Parallelogram Descending and Ascending alternately*; and at the end of every Word (for distinction) to interpose some one of the Nine *Digits*, *viz.* 1, 2, 3, 4, 5, 6, 7, 8, or 9, and at the close of all this *Character* ⊖.

Suppose you would write these Words, to be read in Columbs Descending and Ascending alternately, with a Digit Figure between each Word, and at the End ⊕.

**I have escaped out of the Castle in Disguise, and do lodge at the Ball in the High Street, by the Name of Mary Grice.**

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| □ | ☌ | 5 | ☿ | ☍ | □ | ♎ | 4 | ♈ | ♄ | ☌ | ♀ | ☿ | ☿ | ☍ | ♒ | 7 |
| 7 | ☍ | △ | ♏ | 7 | ☌ | ♀ | △ | △ | 4 | ♈ | ☍ | 5 | ♏ | 4 | ♍ | ♀ |
| ☿ | ♋ | ✱ | 3 | ♃ | 4 | ✱ | ♂ | ♂ | ☍ | ♈ | ☿ | ♎ | 8 | ♊ | ☌ | ♍ |
| ☌ | ☌ | ♏ | ☉ | ☌ | ♊ | □ | 5 | ♀ | ☿ | 7 | 6 | ♏ | ♒ | ☌ | ♉ | □ |
| ✱ | ♃ | 4 | △ | ♎ | □ | ♎ | ♂ | ☍ | ♏ | □ | ☍ | ♍ | ♄ | ☿ | 6 | ♃ |
| ☍ | ♎ | △ | 6 | ♏ | 5 | ☍ | ♊ | 3 | 5 | ♊ | ☿ | ☍ | 4 | ☍ | ☉ | ☍ |
| 3 | ☍ | ✱ | ♏ | ♈ | ☍ | 7 | ♂ | ☌ | ♏ | 5 | ♏ | ☍ | ♏ | 4 | △ | ⊕ |

This way of Writing is far more difficult to be discovered than the former by Letters only, though as much, or more to be suspected when intercepted. Let your Writing be in any Language, it may be by these Characters expressed, and in any form: As suppose I would write this *French* Proverb, in a *Rhomboyades* form, to be read in a *Diagonal* Descending and Ascending alternately:

**Pape par voix, Roy par nature, Empereur par force.**

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | ♋ | □ | ♑ | ☌ | ♏ | ✱ | ♍ |
| | | | | ☌ | △ | 5 | ♊ | ✱ | ☍ | 8 | ☍ |
| | | | ♋ | ✱ | ♍ | 7 | ♍ | ♍ | ♋ | ♃ | |
| | | ☍ | 4 | △ | ♍ | ☍ | ☍ | ☍ | ♍ | | |
| | 7 | ♍ | ♒ | ☌ | 6 | ♋ | ♍ | △ | | | |
| ♋ | ☌ | 4 | ♋ | ☍ | ♉ | 3 | ☉ | | | | |

## IV. *By Knots tyed (or other Marks made) upon a String.*

FOR the effecting of this, the *Two Correspondents* must each of them have a fine thin Board, or piece of Brass, or Copper, made in the form of a *Parallelogram*, or *Long Square*; at one end whereof let be written or engraven the Twenty Four Letters of the Alphabet, either in order, or transposed, which shall be agreed upon; and between each Letter, let there be a faint or occult Line drawn or gauged quite through the Board, or Plate, from end to end, representing Twenty Four Columbs: Also, let the Two longer sides of the Board, or Plate, have Notches cut in it, at about one quarter of an Inch distance from each other; as in the Figure is expressed.

The

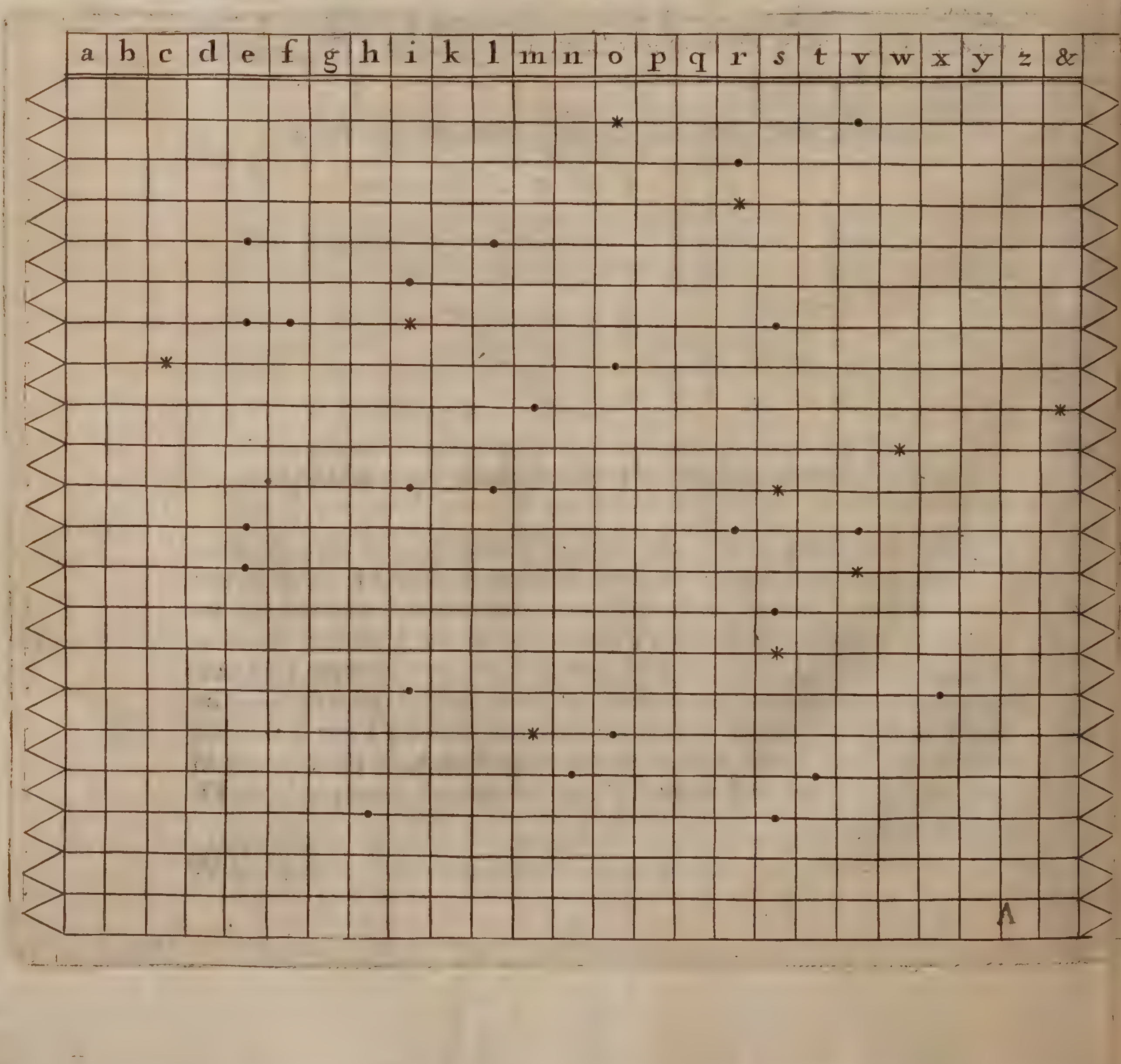
*The Figure of the* Board *or* Plate, *with the Alphabet.*

*a, b, c, d, e,* &c.

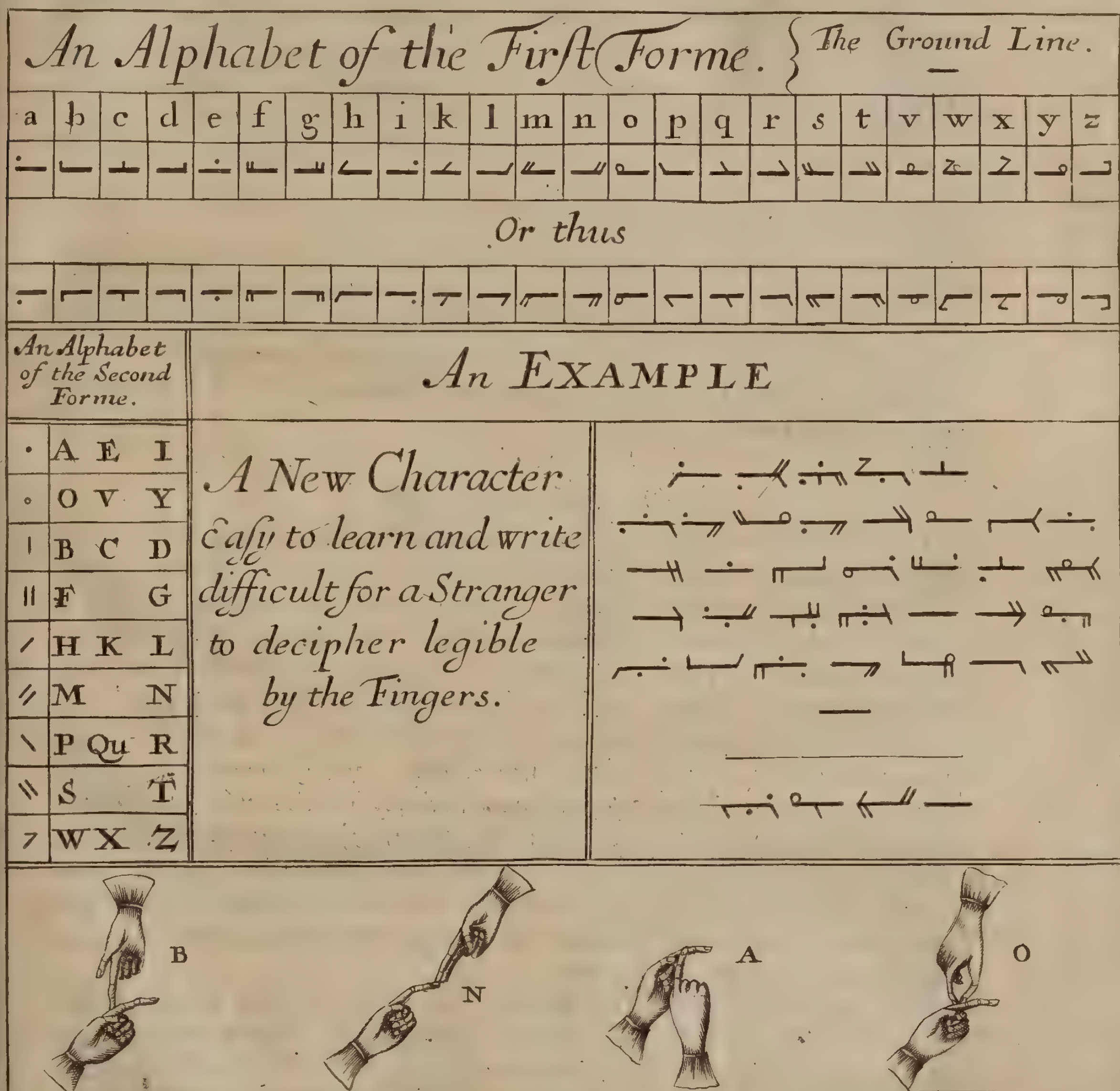
When you would communicate your mind to your Correſpondent, take a Piece of even and well-twiſted Packthread, at one end whereof tie a Nooſe to be put over an Hook towards the top of the Board on the back ſide thereof, made for that purpoſe. Then bring the *String* over at *a*, and bring it to the Notch *b*, and from *b*, over at *c*, and guide it to *d*, and ſo continue till you have as many Lines of String as will contain your intended Writing. The *Board*, and *String* being thus prepared, ſuppoſe you would expreſs theſe Words,

**Our Relief is come, and will ſerve us Six Months.**

Upon *the String*, under the Letter *o*, tie a Knot, or (rather) with a Needle, and ſome light coloured Thread, or Silk, ſtich through that part of *the String* which lies under *o*; do the like under *u*, and in the next line under *r*, ſo have you your firſt word *Our* expreſſed upon the String. And doing ſo with all the reſt, you will find the *Knots* or *Marks* upon *the String* when it is upon *the Board* or *Plate*, as in *the Figure:* Which being taken off, and conveyed to your *Correſpondent* (who knows well enough how to apply it to his *Board*) it will declare your Writing very plainly, and void of all ſuſpicion, if intercepted.



## *A* NEW CHARACTER *Easie to Learn and Write, difficult for a Stranger to decipher, Legible by the Motion of the Fingers, wherein each Line of Writing shall contain Two Lines of Sense.*




EVery Letter of this Alphabet is built upon a ſhort line, thus (—), which, for diſtinction ſake, may be called *the Ground-Line.* The ſeveral letters are formed by the addition of a few ſmall ſtrokes, or points, which repreſent divers letters, according as they ſtand at the *Beginning*, *Middle*, or *End of the Ground-Line.*

I have given the Alphabet in Two Forms ; The firſt as plainer to be underſtood, the ſecond Form as eaſier to be remembred. At the Top of

of the ſecond Alphabet you have a *Point*, or *Speck*, and the letters A E I, which denotes, that a *Point* at *the Beginning* of *the Ground line* (either above it, or under it) ſtands for A, the firſt Letter of the Three. If the *Point* be over (or under) *the Middle* of *the Ground Line*, it is E, the middle Letter; and if over (or under, *the End*, it is I, the third letter at the Right Hand. So in the middle Rank is (′) H K L, which ſhews that this oblique ſtroke (′) ſet at *the Beginning* of *the Ground-Line*, is H, at *the Middle* K, at *the End* L; and ſo of the reſt.

That your Writing may look more gracefully, let all your *Ground-Lines* be at equal diſtances from each other; and when you end a word leave one line blank, as you will ſee in the Example annext.

It will oft fall out, that Two, and ſometimes Three Letters may be expreſt ſucceſſively upon one ſide of *the Ground Line*, *viz.* when after a Letter, whoſe place is at *the Beginning*, another follows immediately, whoſe place is in *the Middle*, or *End* of *the Ground Line*, as you will find in the Syllable *be. ben. ſu. ſun*, *wet*, &c. which Syllables rightly written, will ſeem but one Letter.

When you have written a Line on *the upper ſide* of your *Ground-Line*, begin again on *the under ſide*, and go on with your matter; ſo will every Line be *double written*; which will take up leſs room than other Writing, and render it very difficult to be deciphered.

*Inſtead of more Directions there is an Example in the Scheme foregoing, which follows.*

## *An* EXAMPLE.

The *Character* has a farther Conveniency, that it may be read or expreſt to another perſon by *the Motion of the Fingers*, the *Letters* being ſo framed *that they may be eaſily ſo expreſt*, thus, Let *the fore-finger of* your *left-hand* repreſent *the Ground-line*. Let the *root* of the *Finger* repreſent the *beginning of the Line*, the *middle joynt*, the *middle of the Line*, and the *tip of the Finger*, the *end of the Line*; The ſeveral *letters* are formed by putting the *Fingers* of the *right hand* upon this *ground finger* in ſuch manner as ſhall repreſent the *Letter*. So B is expreſt by putting your *right hand fore-finger* perpendicularly on the *root* of the *left-hand forefinger*. N. is expreſt by putting the two *foremoſt fingers* of the *right-hand* obliquely on the tip of the *left hand forefinger*. *See the figure.*

A E and I are expreſt by laying the End of the Right Fore-Finger In the *Root*, *Middle* and *End* of the Left Fore-Finger, both Fingers lying level, as in the *Figure* at A.

O U and Y are formed by joyning the Tips of your Right Fore-Finger and Thumb, ſo as to make a kind of O, which being ſet at *Beginning*, *Middle* and *End*, is either O, U or Y; as — W X Z are made by crooking, or bending your Right Fore-Finger, to imitate the crooked ſtroke for thoſe Letters.

When you come to the End of a word, you may give a Fillip with your Finger, to intimate as much. By this means Two Perſons may talk to each other without being heard or underſtood by By-ſtanders.

Note, *If you would have this way of Writing peculiar to your ſelf, ſo as that others, who have ſeen this Alphabet, may not read it, you may if you pleaſe, alter the Alphabet, by making the additional ſtrokes*, &c. *ſtand for other letters than here they are put for.*

Some

## *Some other ways of Secret Writing.*

I. IF you take ſome *Salalmonack*, beaten to Powder, and ſteeped in *Vinegar*, and write what you pleaſe therewith upon White Paper, letting it be thorough dry, and nothing will be diſcerned; but hold the Paper a little while againſt the Fire, and you ſhall ſee all that was written, as black as if it had been written with Ink------If you write with the Juice of *Limon* it will do the ſame.

II. Take good *Roach-Allumb*, and boyl (or diſſolve) it in fair Water till it be very ſtrong, then write therewith upon *Venice*, or (thin Paper) what you pleaſe, ſo that when it is thorough dry, nothing will be ſeen: But take the written Paper, and draw it through a Baſon of fair Water, till it be thoroughly wet, and then what you writ will appear as if it were written with White upon the wet Paper.

III. If you write with *Urine*, *Milk*, or ſuch other Glutinous Moiſture, and when it is dry, throw fine Aſhes or Duſt thereupon, rubbing ſoftly upon the Writing, the Words or Letters will appear----Alſo if you write upon the Back of your Hand (or any part of your Body) with *Urine*, take ſome Paper and burn it, and with the Aſhes of the Paper rub the Writing over, and it will be very legible upon your Hand or Body.

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# RECREATIONS Magnetical.

## CHAP. I.

### *Of the* Magnet *or* Load-ſtone; *And of Experiments performed thereby.*

#### I. *Of the Name.*

IT is called *Load-ſtone*, or a Leading Stone, *eſt enim Lapis cujus ducto nautæ curſum inſtituunt* : In the *Germain* Tongue it is called *Seil-Steen* : In *Low-Dutch*, *Segel-Stein* : *i. e. Lapis Navigationes. Magnet-Stein* : In French *Aimánt* : In Spaniſh *Ymán* : In Italian, *Magneté*, *Magneſia* : In Latin Magnes, Magneſius : In Greek μαγνὴς μαγνῆτις, *à Magnete* Inventore. But *Lucretius* writeth that its name is Derived from the Countrey M*agneſia* :

The *Greeks* do call it M*agnes* from the *Place*;
For that the M*agnets* Land it did Embrace.

*Plato* ſaith, ſome call it *Lapis Heraclius*, from the Name of *Heraclea*, a City of *Lydia*, where it was firſt diſcovered; and upon the ſame account *the Touch-ſtone* is called *Lapis Lydiæ*. *Theophraſtes* calleth it *Herculeum* for the ſame Reaſon; and others take it from *Hercules* : *Nicander* and *Pliny*, think it ſo called from one *Magnes*, a *Shepherd*; for it is reported that he found it by chance, his Hob-nail'd Shooes and Crook, ſticking faſt to it, as he was feeding his Flock in *Indea*. Others call it *Siderites*, which in *Greek* ſignifies *Iron*. By us it is called *Load-ſtone*, alluding to *the Two Stars* in *the Tail of the Celeſtial Bear*, called *Helice* and *Cynoſma*, which were anciently called *the Load-ſtars*, or *Leading-Stars*; and this *Stone* performing the Office of thoſe *Stars*, taketh its Name of *Lead*, or *Load-ſtone*.

II. *Where*

## II. *Where these* Stones *are found, and of their* Colour, Weight *and* Force.

THey are found in divers parts of the World, and most commonly in *Iron-Mynes*: Of them there are divers sorts, differing one from another in *Colour*, *Weight*, and *Force* in attraction; but all of them agree in *Property*.

1. The best of these *Stones* come out of *East India*, from the Coasts of *China* and *Belgana*. They are of an *Iron*, or *Sanguine Colour*, *Massy* and *Weighty*. Some of them will attract, or lift up not much above their own weight, but others (well *Capt* and ordered) will take up five, ten, and some twenty times their own weight; and these (being but rarely found) are sold for their weight in Silver in *India*, where they grow.

2. There are some found in *Arabia*, and *the Red Sea*, which grow bread and flat, like a Paving-Tile. They are of a *Reddish Colour*, and are not so weighty as those which grow in *China*, but their Vertue near as good, and will continue long upon a Needle touched on them.

3. Some of these *Stones* are found in the *Levant*, in the Island called *Elba*, near *Purta Feraro*, and are there called *Calamita Preta*, or *Black Magnets*; These have no great Force, neither doth the Vertue they infuse last long.

4. There are others of a *White Colour*, and spungy, like an *Honey-Comb*, found In *High Albany*; they are lighter, but their Vertue is stronger than *the Black ones* before spoken of.

5. Of these *Stones* some are found at *Long-sound*, in *the Iron-Mines* in *Norway*, their Colour *Black*, mixed with *Grey*, but of an indifferent Force.

6. Some there are found in the *Mines* of *Carraca*, and *Cantabria*, in *Spain*; Others in *Bohemia*; and some in the *West* of *England*.

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# CHAP. II.

## *That the whole* Globe *of the* Earth *hath true* Magnetical *Vertue*; *Proved by Experiment.*

1. TAke any Piece of *solid Earth*, that hath some toughness to hold together, and will abide the Fire (as *Brick*, or *Tobaccopipe-Clay*) fashion it in such sort that it be uniformly extended towards both ends (the *Oval* Figure will be very fit for this purpose) put it into a Charcole Fire, increasing the Heat by little and little, and with often blowing make it thoroughly red hot; Let it remain so for half an hour or more, that all superfluous moisture, and adverse qualities may thereby be consumed and separated from it: Then take it forth, and let it cool of it self, being laid upon a *Meridian-line* first drawn upon a Free-Stone elevated according

 to

to the Latitude of the place: And then it is certain, that this piece of *Earth* thus *ordered*, will ſenſibly ſhew you that it hath *true Magnetical Vertue.* For one end of a *Magnetical Needle* will covet towards one end of this prepared Maſs of Earth, and fly from the other: And that End which cooled toward *the South*, will draw the *true North End* of the *Needle*; and that end which cooled towards *the North*, will draw the *true South end* of *the Needle.* And for a farther infallible argument, do thus: Mark (with a piece of Chalk, or the like) what end of *the Maſs* drew *the North* end of *the Needle*, and put it into the Fire again; and when it hath been glowing hot half a quarter of an hour, take it out and cool it, being placed with that marked end towards the *North*; and that end now will draw *the South* end of *the Needle*, and *the North* end of *the Needle* will ſhun it, which before approached unto it.

## CHAP. III.

### *That Magnetical Vertue may be infuſed into a* Needle, *without the help of a* Load-Stone.

IRon being a Mineral of *the Earth*, and having a Sympathetical Quality with *the Loadſtone*, acquiring this Verticity from *the Magnetiſm of the Earth*; as in Bars of Windows which have been of long continuance: Take ſuch a Bar, and file both the ends thereof very ſmooth; then take a ſmall *Needle*, and touch it thereupon, the *South* end of *the Needle* upon *the North* (or upper) end of the Bar, and *the North* end of the *Needle* upon the *South* (or lower) end of the Bar: Such a *Needle* you will find to have reſpect, and conform it ſelf to *the magnetical Meridian* of the *Earth.*

## CHAP. IV.

### *Of the* Attractive *Virtue of the* Loadſtone.

1. IF you apply a piece of *Iron* to either of the *Poles* of a *Load ſtone*, it will here hold it, and at a diſtance will alſo draw, or attract a ſmall piece of *Iron*, according to the Vigor or Indebility of the Stone.

2. Whatſoever ſtrength a *Stone* hath, it may be artificially improved to be greater, by applying two ſmooth and bright pieces of *Iron* to either *Pole* of the *Stone*, unto which *Irons*, the *Stone* will immediately impart its *Vigour*; And the *Stone* by this means will become far more vigorous than it was before theſe *Irons* were applied to its *Poles*, and bound thereto by *Braſs Hoops* or *Bands*, which is called *Capping of a Loadſtone.*

3. A

3. A Piece of *Steel* having received ſtrength from the *Stone*, that will alſo attract another piece of *Steel* to it, in proportion as the Virtue the firſt piece hath received from the *Stone*. For if you touch a *Knife* (being clean) upon the *Stone*, that *Knife* ſhall take up a *Key*, or other bright piece of *Iron* of two *Ounces* weight: And that within the *Sphere* of the *Stones* activity, ſhall deliver the virtue into another piece of *Iron*, cauſing the two pieces of *Iron* to hang one to another.

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## CHAP. V.

### *Of the* Sympathetical *and* Antipathetical Property *of the* Load-Stone.

1. WHen a *Needle* is touched upon a *Load-Stone*, the *North* and *South* ends of this *Needle* will apply themſelves to the *Poles* from whence they received their *Magnetical Life*, *viz.* the *North* end of the *Needle* to the *North* end of the *Stone*, and the *South* end of the *Needle* to the *South* end of the *Stone*; which denotes their mutual *Sympathy*.

2. But putting the *North* end of the *Stone*, to the *South* end of the *Needle*, when it hangs upon a *Pin*, the *South* end of the *Needle* will immediately fly away; and if you put the *South* end of the *Stone*, to the *North* end of the *Needle*, it will there diſcover the *Antipathetical* Nature; for it will fly away from it.

3. But a contrary *Operation* there is yet in the two *Needles* to that of the *Stone*: For if one of the *Needles* being hung upon a *Pin*, if you apply the *North* end of the other *Needle*, to the *North* end of that upon the *Pin*, it ſhall immediately fly away, which denotes a contrary *operation* in the *Needle*, to that of the *Stone*; and the *South* end of the one, will come to the *North* end of the other.

4. The ſame Property of *Sympathetical Coition*, and *Antipathetical Repulſion*, may be alſo diſcovered by two *Load-ſtones*, floating in two little Boats in a Baſon of Water, the two *Poles* of either *Stone* being diſpoſed parallel to the Horizon: And if you put the two *South-Poles* together, they ſhall avoid the contact of one another by a natural *Antipathy*; But if the *North-Pole* of one, be direct to the *South-Pole* of the other, they will immediately manifeſt their natural *Sympathy* one to another, and will cleave together by a ſtrong attraction.

5. This is alſo evident between the great *Magnet* the *Earth*, and a *Load-ſtone*; For if you put a *Load-ſtone* in a *ſtring*, and hang it up in the *Air*; or to float in the *Water* in a *Wooden-Diſh*, and putting the *North* end of the *Small-Magnet*, towards the *North* of the *Great-Magnet* the *Earth*, it ſhall immediately change its Poſition, and turn its *North-Pole* towards the *South-Pole* of the *Great Magnet*.

CHAP.

# CHAP. VI.

## *Several* Consequencies *which follow the various* Cutting, *or* Dividing *of a* Load-Stone.

1. IF a *Load-stone* be casually broken into several *pieces*, every *piece* shall be an entire *Load stone*; having both its *Poles* distinctly in it self, with all the other properties which the other *Load stone* had before it was broken.

2. But if a *Load-stone* be divided in the middle, between the two *Poles*, that is in the *Equinoctial*, then is it absolutely two entire *Load-stones*; but those parts which were the *Equinoctial* before, are now become two *Poles*; and the two *Poles* that were the two *Poles* before, continue to be two *Poles* still.

3. But if a *Load-stone* be cut through a *Meridian*, and consequently through both the *Poles* thereof; so that one *Axis* is now converted into two, and each of them remove into each *Stone* one: And so it is become two absolute *Load-stones*, and the *Axis* of either of them will retire into the gravity of each part: And if you joyn the two pieces together again, the two *Axes* will again become one.

4. But if you cut off a piece of a *Stone* at the very *Pole*, in a parallel Section, the Virtue of that *piece* cut off will immediately retire from it into the main *Stone*, and will have little or no virtue in it; but applying the small piece cut off, to the same place again, the *Stone* will forthwith impart the same virtue as was before into this piece so cut off, so long as it doth abide in that place; but when it is removed, it doth again lose its virtue.

5. Likewise, If you apply a *Weak Stone* to the *Poles* of a *Strong one*; the *Strong Stone* will impart of his *Virtue* to the *Weak Stone*, making it to be as strong as it self, so long as it is his Neighbour; but when this weak *Magnet* deserts this Neighbourly Propinquity, the strong *Magnet* will draw its Virtue to it self again.

# CHAP. VII.

## *How to find the* Poles *of a* Loadstone.

1. TAke a thin piece of *Steel*, about an Inch in length, and a quarter of an Inch broad: This piece of *Steel* being bent Circular, and laid upon the Stone, will immediately lye parallel to the *Axis* of the *Stone*; and direct which way the *Poles* do lye. Which being thus far discovered, you may find them exactly thus. Take a piece of a common sewing *Needle*, which being laid upon the *Stone* near either of the

Poles,

*Poles*, it will elevate one end thereof, then move it farther and farther, till it do erect it self *perpendicular*, and that very Point will be the *Pole* of the *Stone*.——And now to know which *Pole* it is that you have found, apply a *Needle* that hath been touched, and if the *Stone* draw the *North* end of the *Needle* to it, then is that the *North Pole* of the *Stone*; but if the *South* end be drawn, the contrary.—Otherwise, you may find the *Pole* of a *Stone* in this manner; Take a common *sewing Needle*, and thred it, then hang it over the *Stone* where you imagine the *Pole* to be, and keep the Point a little short from the *Stone*, and the *Needle* will point *directly* to the *Pole* of the *Stone*.

2. If you take a small sewing *Needle*, and touch the two ends thereof upon the two *Poles* of the *Load-stone*; then having a *Glass of Water*, lay the *Needle* gently upon the *superficies* of the *Water*, and it will there *swim*. Then take a *Knife* that hath been touched with a *Load-stone*, and move it too and fro upon the edge of the *Glass*, and the *Needle* will follow it up and down, and will play upon the superficies of the *Water*, as a *Fish*; then take away the *Knife*, and the *Needle* will rest upon the *Water*, and in a situation *North* and *South*.

3. If you take two *sewing Needles* touched, and put the Point of one *Northerly*, and the Point of the other *Southerly*, and put them into two small pieces of *Cork*, and put them thus into a *Bason* of *Water*, one on one side, and the other on the other side of the *Bason*, you shall see them as it were quickened with a vital spirit, even so to move one towards another, at the first softly, but when they draw nearer, they will rush together with great violence; the Point of the one striking exactly against the Point of the other.

4. If you take a good large *Brass* or *Pewter Plate*, and upon it place some *filings* of *Steel* or *Iron*, and some small *bits* of *sewing Needles*, and disperse them about the *Plate* in several places; Then take a *Load-stone*, and put it under the *Plate*, with one of the *Poles* upwards, and put it sometimes to one *heap*, and sometimes to *another*, so shall you find them *heaps* to interfere, and clash one against another, being very pleasant to behold.

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## CHAP. VIII.

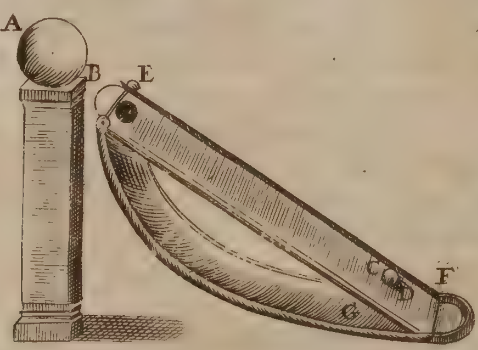
### *Of several Attempts that have been made to contrive a* Perpetual Motion *by* Magnetical Virtues.

IT was the Opinion of *Peter Peregrinus*, That a *Magnetical Globe*, or *Terella*, being rightly placed upon its *Poles*, would of its self have a constant *Rotation*, like the *Diurnal motion* of the *Earth*: But this his Opinion is generally exploded, by common experience.

*Athanasius Kirkerus* thinks it possible to contrive several pieces of *Steel* and a *Load-stone*, that by their continual *Attraction* and *Expulsion* of one another, they may cause a perpetual *Revolution* of a *Wheel*; and of this Opinion were *Peter Peregrinus* above mentioned, *Cardan* and others: But Dr. *Gilbert* concludes it to be a vain and groundless fancy.

Of

Of these kind of Inventions, this which follows is the most likely, wherein a *Load-stone* is so disposed, that it shall draw unto it, upon a *Reclining Plain*, a *Bullet* of *Steel*; which *Steel*, as it ascends near to the *Load-stone*, may be contrived to fall down into a hole in the *Plain*, and so to return unto the place from whence at first it began to move; And being there, the *Load-stone* will again *Attract* it upwards, till coming to this *Hole*, it will fall down again; and so the *Motion* shall be *perpetual*, as may be conceived by this Figure:




Wherein suppose the *Load-stone* to be represented at *A B*, which though it hath not strength enough to *attract* the *Bullet C* directly from the Ground, yet may do it by help of the *Plain E F*. Now, when the *Bullet* is come to the top of this *Plain*, its own *Gravity* (which is supposed to exceed the strength of the *Load-stone*) will make it fall into the *hole* at *E*; and the force it receives in this fall, will carry it with such a violence unto the other end of this Arch, till it will open the Passage there made for it, and by its return will again shut it; so that the *Bullet* (as at the first) is in the same place whence it was first *Attracted*, and consequently must move *perpetually*.

But this Invention, tho' it have such strong probability in it, yet there are some particulars which may render it insufficient.

CHAP.

## CHAP. IX.

### Of Magnetical Inclination, *or of the* Inclinatory (*or* Dipping) Needle: *And thereby to find the* Latitude *at* Sea *or* Land, *without help of the* Sun *or* Stars.

OF the Mariners *Plain Compaſs* I ſhall ſay nothing, it being ſo well known to all Perſons: But of this *Inclinatory* (or *Dipping*) *Needle* much hath not been ſaid; But it was the uſeful Invention of Dr. *Barlow*, Phyſician in Ordinary to Q. *Elizabeth*: Alſo written upon by Dr. *Gilbert*, Dr. *Ridley*, and Mr. *Edward Wright*, who hath a *Geometrical Demonſtration* of the Natural Reaſon thereof; and laſtly by Mr. *Henry Bond*, who hath applied it to the finding of the *Longitude* as well as the *Latitude*.

This Inſtrument is now contrived ſo, as to hang in a broad *Braſs Ring*, within two *Glaſſes*, to keep the *Needle* from the *Air*: In the *Braſs Ring* are two *Quadrants* divided into 90 *Deg.* and the *Needle* hangs upon an *Axis*, playing upon two *Pevets*: And the Inſtrument hangs in a Box ſo ordered, that the Ship moving up and down, the Inſtrument hangs Perpendicular in reſpect of the *Ring*, and horizontal in reſpect of the *Box* (or *Compaſs*).

The *Needle* in this *Braſs Ring* between the two *Glaſſes* (before it is touched with the *Load ſtone*) is made to hang upon its *Axis Horizontally*; but when it is touched it hath an *Inclination*, reſpecting a certain *point* of *Elevation* or *Depreſſion*, according to the *Latitude* wherein it is at any time uſed: And the *Depreſſions* are ſuch, in every degree of *Latitude*, as in his *Table* are exhibited.

## *A Table of* Magnetical Inclination.

| Latitude. | Magnetical Inclination. | | Latitude | Mag. &c. | | Latitude | Mag. &c. | | Latitude | Mag. &c. | | Latitude | Mag. &c. | | Latitude | Mag. &c. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| D | D | M | D | D | M | D | D | M | D | D | M | D | D | M | D | D | M |
| 1 | 2 | 11 | 16 | 30 | 45 | 31 | 52 | 27 | 46 | 68 | 24 | 61 | 79 | 29 | 76 | 86 | 28 |
| 2 | 4 | 20 | 17 | 32 | 24 | 32 | 53 | 41 | 47 | 69 | 17 | 62 | 80 | 4 | 77 | 86 | 48 |
| 3 | 6 | 27 | 18 | 34 | 0 | 33 | 54 | 53 | 48 | 70 | 9 | 63 | 80 | 38 | 78 | 87 | 8 |
| 4 | 8 | 31 | 19 | 35 | 36 | 34 | 56 | 4 | 49 | 70 | 59 | 64 | 81 | 11 | 79 | 87 | 26 |
| 5 | 10 | 34 | 20 | 37 | 9 | 35 | 57 | 13 | 50 | 71 | 48 | 65 | 81 | 43 | 80 | 87 | 44 |
| 6 | 12 | 34 | 21 | 38 | 41 | 36 | 58 | 21 | 51 | 72 | 36 | 66 | 82 | 13 | 81 | 88 | 1 |
| 7 | 14 | 32 | 22 | 40 | 11 | 37 | 59 | 28 | 52 | 73 | 23 | 67 | 82 | 43 | 82 | 88 | 17 |
| 8 | 16 | 28 | 23 | 41 | 39 | 38 | 60 | 33 | 53 | 74 | 8 | 68 | 83 | 12 | 83 | 88 | 33 |
| 9 | 18 | 22 | 24 | 43 | 6 | 39 | 61 | 37 | 54 | 74 | 52 | 69 | 83 | 40 | 84 | 88 | 47 |
| 10 | 20 | 14 | 25 | 44 | 30 | 40 | 62 | 39 | 55 | 75 | 35 | 70 | 84 | 7 | 85 | 89 | 1 |
| 11 | 22 | 4 | 26 | 45 | 54 | 41 | 63 | 40 | 56 | 76 | 17 | 71 | 84 | 32 | 86 | 89 | 14 |
| 12 | 24 | 52 | 27 | 47 | 15 | 42 | 64 | 39 | 57 | 76 | 57 | 72 | 84 | 57 | 87 | 89 | 27 |
| 13 | 25 | 38 | 28 | 48 | 36 | 43 | 65 | 38 | 58 | 77 | 37 | 73 | 85 | 21 | 88 | 89 | 39 |
| 14 | 27 | 21 | 29 | 59 | 54 | 44 | 66 | 15 | 59 | 78 | 15 | 74 | 85 | 44 | 89 | 89 | 50 |
| 15 | 29 | 43 | 30 | 51 | 11 | 45 | 67 | 30 | 60 | 78 | 52 | 75 | 86 | 7 | 90 | 90 | 00 |

### *The Use of the Table.*

Suppofe you were at Sea in an unknown Latitude, and would find it by this Inftrument and Table.——Your Inftrument being fitted, and the Fly in the Box, and the *Brafs Ring* to hang directly *North* and *South*; Then look how much you find the *North* end of the *Needle* in the *Ring* to be depreffed (which fuppofe to be 63 *deg.* 40 *m.*) find thefe *degrees* and *minutes* in the *Table*, under the Title of [ *Magnetical Inclination* ] and againft it you fhall find 41 *deg.* which tells that you are in 41 *deg.* of *North Latitude*, becaufe the *North* end of the *Needle* is depreffed: For if the *South* end had been fo much depreffed, you had then been in 41 *deg.* of *South Latitude.*

RECRE-

# RECREATIONS Chymical.

## CHAP. I.

### *Of Artificial Repreſentations.*

THE Grounds and Principals of *Chymical Philoſophy* go thus: That *Salt, Sulphur* and *Mercury* are the Principles into which all things do reſolve; and that the Radical and Original Moiſture whereby the firſt principle of *Salt* conſiſteth, cannot be conſumed by *Calcination*; but the forcible Tinctures and Impreſſions of things, as *Colour, Taſte, Smell*; nay, and *the very Forms themſelves*, are inviſibly kept in ſtore in this firm and vital Principle. To make this good by Experiment, They take a *Roſe, Julyflower*, or any kind of Plant whatſoever; they take this Principle in the Spring time, in its fulleſt and moſt congruous conſiſtence; they beat the whole Plant in a Mortar, Roots, Stalks, Leaves and all, till it be reduced to a confuſed Maſs. Then after *Maceration, Fermentation, Separation*, and other workings of Art, there is extracted a kind of Aſhes, or Salt including theſe Forms and Tinctures under their Powers and *Chaos*. Theſe Aſhes are put up into Glaſſes, written upon with the ſeveral Names of the Herbs or Plants; and ſealed *Hermetically*; that is, the Mouths of the Glaſſes heated in the Fire, and then the Neck of it wrung about cloſe; this they call the Seal of *Hermes* their Maſter. When you would ſee any of theſe Vegitables again, they apply a Candle, or ſoft Fire to the Glaſs, and you ſhall preſently perceive the Herbs or Plants, by little and little to riſe up again out of their Salt or Aſhes, in their ſeveral proper forms, ſpringing up as at firſt, they did in the Field or Garden (but in a ſhorter time.) But remove the Glaſs from the Fire, and they immediately return to their own Chaos again.

Now although this went for a great Secret in the time of *Quercetan*, yet *Gaffarell* ſaith, that now 'tis no ſuch rare matter; for Monſieur *de Claves*, a moſt excellent Chymiſt of theſe days (and others) uſes to make ſhew of them at any time.

## CHAP. II.

### *To preserve Fire as long as you will, in imitation of the inextinguishable Fire of* Vestales.

HAving Extracted the Burning Spirit of the *Salt* of *Jupiter*, by the degrees of Fire, according to the Rules of *Chymestry:* The Fire being kindled of it self, break the *Limbeck*, and the Irons which are form'd at the bottom will flame, and appear as burning Coles, as soon as they feel the Air; the which Fire, if you promptly inclose in a Vial of Glass, and close it up with *Hermes* Wax, to prevent Air getting in; then will it keep Fire for a thousand years; yea, if it be kept under Water, or in a Cave, Vault or Cell: But if you open it and let in the Air, the Fire quickly extinguishes.

## CHAP. III.

### *To make the Philosophers Tree.*

TAke two Ounces of *Aquafortis*, and dissolve it in half an Ounce of fine *Silver* refined in a *Cappel:* Then take one Ounce of *Aquafortis*, and two Drachmes of *Quick-Silver*, which put in it, and mix these two dissolved things together; then cast it into a Viol of half a Pound of Spring Water; which must be well stopped: And then may you every day see it grow both in the *Tree* and in the *Branch*.

## CHAP. IV.

### *Of the Re-animation of Simples, when (by reason of the great distance of Places) the Plants cannot be transported.*

TAke the *Simple*, *Root*, *Stalk* and *Branches*; Burn all and take the *Ashes* of it; which let be *Calcinated* two hours between two *Cressets*, well *Luted*, and extract the *Salt*; that is, to put Water into it in moving of it, then let it settle; and do it so two or three times: Afterwards *Evaporate* it, that is, let the Water be Boiled in some Vessel, until it be all consumed, and then there will remain a *Salt* at the bottom; which

which afterwards Sow in good Ground well prepared, and you ſhall have the Plant grow.

## CHAP. V.

### *Of the making of the Epitomy (or repreſentation) of the Great World.*

DRaw *Salt-Niter* out of *Salt Earth*, digged on the Shores (if you can) where are Minerals of Gold and Silver; Mix this *Niter* (being firſt well cleanſed) with *Jupiter*, and Calcine them *Hermetically*; then put it into a *Limbeck*, whoſe Receiver let be of Glaſs, and both well Luted together; but at the bottom of the Receiver you muſt put ſome Leaves of Gold; Then put Fire under the Limbeck, until Vapours ariſe, which will cleave unto the Gold; Augment your Fire till there aſſend no more: Then take away your Receiver, and cloſe it Hermetically; and make a Lamp Fire under it, and in a ſhort time you ſhall ſee preſented to you, almoſt all things which Nature affords; *viz.* Trees, Flowers, Fruits, Fountains, the Sun, Moon, Stars, *&c.*

### *To make a Perpetual Motion.*

*Paraſelſus* and his Followers have bragged, that by their *Separations* and *Extractions* they can make a *Little World*, which ſhall have the ſame perpetual *Motions* with this *Microcoſme*, with the repreſentation of all *Meteors*, *Thunder*, *Snow*, *Rain*, the *Courſes* of the Sea in its *Ebbs* and *Flows*, and the like; and one of them I find in the 118 *Prop.* of the *Etteneary* of *Mathematical Recreations*; which is this, Mix Five Ounces of ☿ with an equal weight of ♃, grind them together with Ten Ounces of *Sublimate*; diſſolve them in a Celler upon ſome *Marble* for the ſpace of four days, till they become like *Oil-Olive*; Diſtil this with Fire of Chaff, or Driving Fire, and it will ſublime into a dry ſubſtance; and ſo by repeating of theſe *Diſſolvings* and *Diſtillings*, there will be at length produced divers ſmall *Attams*, which being put into a Glaſs well Luted, and kept dry, will have a *Perpetual Motion*.

CHAP.

## CHAP. VI.

### *Of a famous Perpetual Motion invented by* Cornelius Dreble, *and made for K.* James I. *wherein was represented the constant* Revolutions *of the* Sun *and* Moon, *and that without the help either of* Spring *or* Weight.

M*Arcellus Vranckhein* ſpeaking of the means whereby it was performed, he calls it *Scintillula animæ Magneticæ Mundi, ſeu Aſtralis & inſenſibilis ſpirittis:* Being that grand ſecret which thoſe Dictators of Philoſophy, *Democritus*, *Pythagoras* and *Plato* did Travel to the Gymnoſophiſts and *Indian* Prieſts. The Author himſelf does not reveal the way how it was performed: But one *Thomas Tymme*, (one that did often pry into his works) affirms it to be done thus; By extracting a Fiery Spirit out of the Myneral Matter, joyning the ſame with his proper Air, which included in the Axle-Tree (of the firſt moving Wheel) being hollow, carrieth the other Wheels, making a continual Rotation, except iſſue or vent be given to this hollow Axle-Tree, whereby the impriſoned Spirit may get forth.

*But theſe, and ſuch like miraculous promiſes, would require as great a Faith to believe them, as a Power to perform them.*

## CHAP. VII.

### *Of the making of* GOLD.

COncerning this Matter, I ſhall only ſet down (in his own Words) the *Opinion* of the Right Honourable *Francis* Lord *Verulam*, Viſcount St. *Alban*, in his *Natural Hiſtory*, Century IV. and *Experiments Solitary*, touching the *Making of* GOLD.

The World (ſaith he there) hath been much abuſed by the Opinion of *Making of Gold:* The *Work* it ſelf I Judge to be poſſible; But the *Means* (hitherto propounded) to effect it, are, in the *Practice*, full of *Error* and *Impoſture:* And in the *Theory*, full *of unſound Imaginations:* For to ſay that *Nature* hath an Intention to make all Metals *Gold:* And that, if ſhe were delivered from Impediments, ſhe would perform her own Work: And that if the Crudities, Impurities and Leproſities of *Metals* were cured, they would become Gold: And that a little *Quantity* of the *Medicine*, in the Work of Projection, will turn a Sea of the *Baſer Metal* into *Gold*, by Multiplying: All theſe are but Dreams;

Dreams; and ſo are many other Grounds of *Alchymy*. And to help the Matter, the *Alchymiſts* call in likewiſe many Vanities, out of *Aſtrology*, *Natural Magick*, Superſtitious Interpretations of *Scripture*; Auricular *Traditions*; Feigned Teſtimonies of *Ancient Authors*; and the like. It is true, on the other ſide, They have brought to light not a few profitable *Experiments*, and thereby made the World ſome amends. But we, when we ſhall come to handle the *Verſion*, and *Tranſmutation* of *Bodies*: And the *Experiments* concerning *Metals*, and *Minerals*; will lay open the true Ways and Paſſages of *Nature*, which may lead to this *Great Effect*. And we commend the Wit of the *Chineſes*, who deſpair of making *Gold*, but are mad upon making of *Silver*: For certain it is, that it is more difficult to make *Gold* (which is the moſt Ponderous and Materiate amongſt *Metals*) of other *Metals*, leſs Ponderous, and leſs Materiate: then (*viâ verſâ*) to make *Silver* of *Lead*, or *Quickſilver*; both which are more ponderous than *Silver*: So that they need rather a further degree of *Fixation*, then any *Condenſation*. In the mean time, by occaſion of handling the *Axioms* touching *Maturation*, we will direct a *Trial* touching the *Maturing* of *Metals*; and thereby turning ſome of them into *Gold*: For we conceive, indeed, that a perfect good *Concoction*, or *Digeſtion* of *Maturation* of ſome Metals, will produce *Gold*. And here we call to mind, that we knew a *Dutch-man*, that had wrought himſelf into the belief of a Great Perſon, by undertaking that he could make *Gold*: Whoſe Diſcourſe was, That *Gold* might be made, But that the *Alchymiſts* Over-fired the Work: For (he ſaid) the making of *Gold* did require a very temperate *Heat*, as being in *Nature* a Subterrany work, where little *Heat* cometh; but yet more to the making of *Gold*, then of any other Metal; And therefore, that he would do it with a Great *Lamp*, that ſhould carry an Equal and Temperate Heat: And that it was the work of many Months. The device of the Lamp was Folly; but the Over-firing now uſed, and the equal Heat to be required, and the making it a work of ſome good Time, are no ill Diſcourſes.

We reſort therefore to our *Axioms* of *Maturation*, in effect touched before: The firſt is, That there be uſed a *Temperate Heat*, for they are ever *Temperate Heats* that *Diſgeſt* and *Mature*, wherein we mean *Temperate*, according to the *nature* of the *Subject*; For that may be *Temperate* to *Fruits* and *Liquors*, which will not at all work upon *Metals*. The ſecond is, That *the Spirit of the Metal be quickned*, and the *Tangible parts opened*: For, without theſe two Operations, the *Spirit* of the *Metal* wrought upon, will not be able to diſgeſt the parts. The Third is, That *the Spirits do ſpread themſelves even*, and *move not ſubſultorily*; For that will make the Parts Cloſe and Plyant. And this requires a *Heat*, that doth not riſe and fall, but continue as *Equal* as may be. The Fourth is, That *no part of the Spirit be emitted, but detained*. For, if there be *emiſſion* of *Spirit*, the Body of the Metal will be Hard and Churliſh: And this will be performed, partly by the temper of the Fire, and partly by the cloſeneſs of the Veſſel. The Fifth is, That there be *Choice made of the likelieſt and beſt prepared Metal, for the Verſion*: For that will facilitate the work. The Sixth is, That you *give Time enough for the Work*: Not to prolong hopes, (as the *Alchymiſts* do) but, indeed, to give *Nature* a convenient ſpace to work in: Theſe Principles are moſt Certain and True. We will now derive a direction of *Tryal* out of them,

them, which may (perhaps) by further meditation, be improved.

Let there be a small *Furnace* made, of a *Temperate heat*; let the *heat* be such as may keep the *Metal perpetually Molten*, and no more; for that, above all, importeth to the Work. For the Material, take *Silver*, which is the *Metal* that in *Nature* Symbolizeth most with *Gold*; Put in also with the *Silver*, a Tenth part of *Quick-Silver*, and a Twelfth part of *Nitre* by Weight; both these to Quicken and Open the Body of the *Metal*: And so let the Work be continued by the *space of six Months* at least. I wish also that there be, at some times, an Injection of some *Oyled* substance; such as they use in the recovering of *Gold*, which by vexing with Separations hath been made Churlish: And this is to lay the parts more Close and Smooth, which is the main Work: For *Gold* (as we see) is the Closest (and therefore the Heaviest) of *Metals*: And is likewise the most Flexible and Tensible.

*Note*, That to think to make *Gold* of *Quick-Silver*, because it is the heaviest, is a thing not to be hoped; For *Quick-silver* will not endure the Manage of the *Fire*. Next to *Silver*, I think *Copper* were fittest to be the *Metal*.

### *Concerning the Nature of* GOLD.

Gold hath these Natures: *Greatness of Weight*; *Closeness of Parts*; *Fixation*; *Pliantness*, or *Softness*; *Immunity from Rust*; *Colour or Tincture of Yellow*. Therefore, the sure way (though most about) to make *Gold*, is to know the *Causes* of the several *Natures* before rehearsed, and the *Axiomes* concerning the same: For if a Man can make a *Metal* that hath all these Properties, Let Men dispute, whether it be *Gold* or no?

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## CHAP. VIII.

## *Of Incombustible* Flax, *or a Substance which will not consume by Fire.*

HAving in the foregoing Section spoken of *Subterranean Lamps*, I will here say something concerning a Substance which will not consume by Fire: There was anciently a kind of Flax which the *Grecians* called *Asbestinum*, the *Latines Linum vivum*: Hereof were made whole Pieces of Linnen Cloath, and Garments, which were not only not consumed by any Fire, but being cast into the same, the Soil and Filthiness being consum'd and burn'd away, taken out again, it became more white than any Water could wash it. The Bodies of Emperors and Kings were buried in Sheets of this Linnen, lest the Ashes of their Bodies burned, should mingle with the Ashes of the wood wherewith the Body was burned. This Flax, saith *Pliny*, is hard to be found, and as difficult to be Woven, by reason of the shortness thereof; and being found, in price it equalled the most excellent Pearls. *Nero* is reported to have had a Linnen Garment of the same; but at this day it is not any where to be found. Yet I remember, (saith my Author *H. P.*) I had given

given me by an *Arabian* in the year 1618. a pretty quantity of a Stuff like Flax, which he bad me put into the Fire, but it consumed not: Whither it were of this Flax or no, or that Flax of *Cyprus*, which *Pondecatarre*, a Knight of *Cyprus*, who wrote an History of *Cyprus*, *Anno* 1566. brought to *Venice*, and the Fire could not consume it, I know not. Now this Flax of *Cyprus* proceedeth from no Plant, as our Flax, but from the Stone *Amiantus*, which being found in *Cyprus*, and broken with an Hammer (the Earthy Drofs being purged from it) there remains fine Hairy Threads like unto Flax, which are Woven into Cloath. This Flax was feen in the Houfe of the faid *Pondacatarre* by many Men of Worth and Credit, as *Porcatio* witneffeth, *Tab.* 2. *Euneralium*. Wherefore Linnen being made of the Flax or Threads of this Stone, muft needs be incumbuftible.——*Conftantine* the Emperor ordained that it fhould ever burn in *Lamps* in his Chappel, at *Rome*: This Reports *Damafcus* in the Life of Pope *Sylvefter*. Moreover *Ludovicus Vives*, in his Commentaries upon St. *Auguftins de Civitate Dei*, *Lib.* 21. *c.* 6. faith, That he faw Lamps at *Paris* whofe Lights never confumed. Alfo at *Lovain*, a fowl Napkin taken from the Table at a Feaft, and thrown into the Fire, and being quite Red as a Coal, was taken out again, cooled, and reftored to the owner, more White than if it had been wafhed with Water and Soap: And the like my felf have heard, That a Cook dreffing of a Dinner at a Nobleman's Houfe, whofe Lord was to Dine there; The Noble-Man feeing this ftrange Cook with a Greafie Apron and fowl Sleeves, faid to him, That if the Perfons that were to Dine with him fhould fee his Beaftly Accoutrements, they would loath to eat the Meat that he fhould drefs; whereupon the Cook pulls off his Apron and Sleeves, and throws them into the Fire, which in a very fhort time were made Red-hot, and being taken out and cooled, became White as Snow. And now to conclude this matter, I remember that about the year 1648, or 9, I was in company at a Tavern with fome Gentlemen, and one of the Company took out of his Pocket a piece of a kind of a Stone, about the bignefs it was of a Wall-nut, the outfide whereof was of a dirty Earthy Colour; but the infide of a bright Afh-colour, not much unlike Steel when a Bar of it is new broken; and for weight it did ponderate equal with Steel: Off of the infide of this piece of Stone, feveral of the Company (my felf for one) did with our Knives fcrape off a kind of Woolley, foft Flax, and putting it to the Candle, there burning, it became immediately Red-hot, but no way confumed or diminifhed, but came out of the Fire White, whereas it was in the Stone of a bright Afh-colour, as I faid before.

## CHAP. IX.

### *Some Relations concerning Subterraneous Lamps.*

1. ST. *Austine* mentions one of them in a Temple dedicated to *Venus*, which was always exposed to the open weather, and could never be consumed or extinguished.

2. *Puncirollus* mentions a Lamp found in his time, in the Sepulchre of *Tullia*, *Cicero's* Daughter, which had continued there for above 1550 years; but was presently extinguished upon the admission of new Air.

3. It is related of *Cedrenus*, that in *Justinian's* time there was a Lamp found in a Wall at *Edessa*, which had remained so for above 500 years, there being a *Crucifix* placed by it; from whence it should seem, that these *Lamps* were of use amongst some Christians.

4. *Olybius* his Lamp, which had continued burning for above 1500 years; the Story is this: A Rustick digging the Ground in *Patavia* in *Italy*, he discovered a very Ancient Monument, and in it an *Urn*, or *Earthen Pot*, in which there was another *Urn*, and in this lesser, a *Lamp* clearly burning; on each side of it there were two other *Vessels*, each of them full of a pure *Liquor*, the one of Gold, the other of Silver: And the most Learned of that Age coming to the Monument, affirmed the same to be that Perpetual Fire invented by the wonderful industry of the Ancient Pnilosophers, which would indure so many years. In which Opinion they were confirmed by Verses written in either *Urn*, which seemed to be of great Antiquity by their vein:

These were in the Bigger Urn:

*Plutoni Sacrum munus, ne attingite fores;*
*Ignotum est vobis, hoc quod in Orbe latet.*
*Namq; elementa gravi, clausit digesta labore,*
*Vase sub hoc modico,* Maximus Olibius;
*Adsit facundo, custos tibi copia cornu,*
*Ne pretium tanti, depereat laticis.*

These were in the Lesser Urn.

*——Abite hinc pessimi fures,*
*Vos, qui voltis vestris cum oculis emissisciis;*
*Abite hinc, vestro cum* Mercurio *petasato, caduce*
*Atoq;* Maximus, *maximo domum* Plutoni, *hoc*
*Sacrum facit.*

One *Matarants* had the possession of these after they were taken up.

5. *Baptista*

5. *Baptista Porta* tells us of another Lamp burning in an old Marble *Sepulchre*, belonging to some of the Ancient *Romans*, inclosed in a *Glass Vial*, found in his time, about the year 1550. in the Isle of *Nesis*, which had been buried there before our Saviour's coming.

6. In the Tomb of *Pallos* the *Arcadian*, who was slain by *Turnus* in the *Trojan-Wars*, there was found another *Burning Lamp*, in the year of our Lord 1401. whence it should seem it had continued above 2600 years, and being taken out, it did remain burning, notwithstanding either *Wind* or *Water*, with which some did strive to quench it; neither could it be extinguished till they had spilt that Liquor which was in it.

7. *Ludovicus Vives*, tells us of another Lamp, that did continue burning for 1500 years, which was found a little before his time.

8. There is a relation of a certain Man, who digging somewhat deep in the Ground, did meet with something like a Door, having a Wall on each hand of it; from which having cleared the Earth, he forced open the Door; upon this there was discovered a fair *Vault*, and towards the farther side of it, the *Statue* of a *Man* in *Armor*, sitting by a *Table*, leaning upon his Left Arm, and holding a *Scepter* in his *Right-hand*, with a *Lamp* burning before him: The Floor of his *Vault* being so contrived, that upon the first step into it, the *Statue* would erect it self from his Leaning Posture; upon the second step it did lift up the *Scepter* to strike: And before a Man could approach near enough to take hold of the *Lamp*, the *Statue* did *strike*, and beat it to Pieces.

9. *Cambden* relates in his description of *York-shire*, speaking of the Tomb of *Constantius Chlorus* broken up in these later years, mentions such a *Lamp* to be found within it.

10. In most of the ancient *Monuments*, there is some kind of *Lamp*, tho' of the ordinary sort: But those Persons that were of greatest *Note* and *VVisdome*, did procure such as should last without supply, for so many *Ages* together. And,

11. *Pancirollus* tells us, that it was usual for the *Nobles* among the *Romans*, to take special care, in their *Last Wills*, that they might have a *Lamp* in their Monuments.

12. St. *Augustine* tells us, that in the Temple of *Venus* was a *Lamp* that never went out, which he supposed to have been done, either by Art *Magical*, or by industry of some Man, who had put *Lapidem Asbestum*, or the unquenchable Burning-Stone within the same Lamp.

Concerning these Lamps found burning in Graves, I wonder, (1.) How by the help of Art (for Chymists say this Oyl is made of Gold.) Gold may be resolved into a Fatty substance! (2.) How the Flame should endure so many years! (3.) How within the Ground, all Air being excluded.

# RECREATIONS Automatical.

## CHAP. I.

### *Of the Nature and Making of* Watches, Clocks, *and other* Movements.

THE Precepts following are ſuch as were by Sir *Jonas Moor*, Extracted out of a Manuſcript of Mr. *William Oughtreds*, by him made for his Sons private Uſe, he being of that Profeſſion.

The *Great Wheel* whereon the *Fuſie* or *String* with *Weights* are fixed, divides the Nature of the Work in any *Movement*: That is to ſay, All the *Wheels* and *Pinions* from that *Great Wheel* to the *Ballance* or *Fly*, only prepare the *Motion*, but the other way effect it: In purſuance whereof, two things are to be noted.

1. The *Fuſie*, and how many *Turns* it hath.
2. The *Number* and *Names* of the *Wheels*, *Teeth* and *Pinions*.

*Example*: In a *Watch* of *Four Wheels*: Suppoſe the Numbers following to be the *Teeth*:

Firſt, The *Great Wheel* [Number 55. *Teeth*] Turning the *Pinion* [Number 5.] fixed to the *ſecond Wheel*.

Secondly, The *Second Wheel* [Number 45.] turning the *Pinion* [Number 5.] fixt to the *Contrat Wheel*.

Thirdly, The *Contrat Wheel* [Number 40.] turning the Pinion [Number 5.] fixt to the *Crown Wheel*.

Fourthly, The *Crown Wheel* [Number 17.] having Odd Teeth, working upon the Pallots of the *Ballance* [Number 2.]

Thus for *Watches* of *four Wheels*: But for *Watches* with *five Wheels*, there will be a Third Wheel before the *Contrat Wheel*.

Fifthly, The *Pinion of Report*, fix'd to the *Arbor* of the *Great Wheel* [Number 4.] which lies hid betwixt the Plates in Watches, and turns the *Hour-Wheel* [Number 36.] which carries the *Hand* about upon the *Face*; divided into 12 or 24 Hours.

For brevities ſake, let

M Stand for *Movement*, whether *Watch* or *Clock*.
F The *Fuſie*.
A The *Great VVheel*.
a The *Pinion* of *Report* on the *Arbor*.
E The *Second VVheel*.
e The *Pinion* on its *Axis*.
I The *Contrat VVheel*.
i The *Pinion* on its *Axis*.
O The *Crown-Wheel*, carrying
o Its *Pinion* on its *Axis*.
B The *Dial-VVheel* carrying the *Hand* in 12 hours.
T *Time*.
t *Turns*.
N *Notches*, or *Beats* of the *Ballance*.
Con. *Continuance*, and Length in *Time* of the Watches going.

The Work ſtands both in *Letters* and *Figures*, as in the *Example*.

*a*) *B* (*d* 4) 36 (9
*e*) *A* (*f* 5) 55 (11
*i*) *E* (*g* 5) 45 (9
*o*) *I* (*k* 5) 40 (8
O 17 *Crown VVheel*
2 *Pallats*.

Where every Wheel is Divided by the *Pinion* it moves from, *A* the Great Wheel, to *O* the Crown-Wheel, *viz.* 55, by 5 equal to 11, equal to *f* 5.— 45 69 5 equal to 8, equal to *k*— But *B* divided by *a* gives 9, that is, *B* by *a*, equal to *d*.

## RULE I.

WHere *f* 11, *g* 9, *k* 8, *o* 17, and 2 *Pallats* Multiplyed into each other ſucceſſively, produce 26928 equal to *N*, the *Notches* or *Beats* made in one Turn of the *Great VVheel*: And 26928 Multiplied by 9, is equal to 242352, the *Beats* that are made in one turn of the *Hand*, whether 12 or 24---- Laſtly, Divide 242352 by 12, it gives 20196, the *Beats* in one *Hour*; and 20196 Divided by 60, gives 336.6, the *Beats* in one *Minute*. All this is plain enough, and is the foundation of the whole Work, and by it may be eaſily found how many *Turns* any *Wheel* or *Pinion* makes for one *Turn* of the *Fuſie* or *Hour-wheel*.

## RULE II.

| | |
|---|---|
| AS the *Beats* for one *Turn* of the *Great Wheel*, or *Fuſie*. | 26928 |
| Is to the *Beats* gone in one *Hour* | 20196 |
| So is the Continuance of the *Time* of the *Watches* going | 16 ho. |
| To the Quotient of the *Hour-Wheel* divided by *a*, the *Pinion* of *Report*. | 9 |

These

These Proportions holding, then any Three given (not of the same kind) you may find a Fourth. As by *Example.*

*To know the Continuance of the* Watches *going, that hath* 12 Turns *in the* Fusie, *and* 26928 Beats *in one* Turn, *and* 20196 Beats *in an Hour.* Say,

As the number of *Beats* of the *Ballance* in an Hour
Is to the number of *Turns* in the *Fusie,*
So is 12 *Turns* of the *Fusie*
To the *Continuance of Time* of the *Watches* going.

For 20196 : 26928 :: 12 : 16.

But if it be demanded by the *Beats,* and the *Time* of the *VVatches going,* to know the *Turns* of the *Fusie:* Then it will be,

As 26928 : 20196 : 16 : 12.

Or, if it be demanded what *Quotient* shall be laid upon the ***Pinion*** of *Report.* Then say,

As 16 : 12 : : 12 : 9
Or, 26928 : 20196

*Note,* That the fewer *Beats* are taken, the longer shall be the *Continuance* of the *VVatches* going at an *Equal Time.*

## RULE III.

### *Concerning* PENDULUMS.

THE *Spring* in a *Watch* drawing harder at the first, than at the last: And likewise in *Clocks* with *VVeights* and *Strings,* there is added the weight of the *String* gotten every moment to the *Clock VVeight*; and for that no *Motion* can be Made by hand so fit, but there will come some unequalness, as you may hear by the *Beats* either of *VVatch* or *Clock.* To justen and regulate these inequalities, Monsieur *Hugens* invented the way of applying *Pendulums* to either, for which his name will be ever in venerable esteem.

*Pendulums* whose *Vibrations* are of the same Degree and Minute, are *Equal,* or if they rise not above a Degree; And the Squares of their *Vibrations* are in proportion to their *Lengths*: For a *Standard* or *Rule,* the aforesaid Monsieur *Hugens* gives the length of a *Pendulum* that shall *Swing Seconds,* to be 881 to the *Parisian Feet,* 864. The *English Feet* to *Paris Feet* by a Table of Sir *Jonas Moors* are, As 1000 to 1068, Therefore, As 864 : 881 :: 1.068 : 1089 : And 1.089 Multiplyed by 3, is equal to 3.267, *i. e.* equal to *Three Feet, Three Inches, and two Tenths of an Inch.*

The late Honourable Lord *Bruncker*, and Mr. *Hook*, found the Length to be 39 Inches, and .325 Parts, which a little exceedeth the other, and it may be was justued by Monsieur *Hugen's* Rule for the Center of *Oscillation*: For *Montons* Pendulum that shall Vibrate 132 times in a Minute, it will be found likewise 8.1 Inches, agreeing to 39.2 Inches, *English*: Therefore, for certain, 39.2 Inches may be called, *The Universal Measure*; and relyed upon to be the neer *Length* of a *Pendulum* that shall *Swing Seconds* every *Vibration*: With this *Caution* and *Rule.*

As

As the length of the *String* from the point of the Suspension to the Centre of a *Round-Ball*,
Is to the *Radius*;
So is *Radius*
To a Fourth Number.

Let two Fifths of that *fourth Number*, be added to the former *Length*, for the *Length* of the *Pendulum*. Having this Standard.

## *The next* RULE *is this.*

THat the *Lengths* of two *Pendulums*, are in Proportion to the *Squares* of their several *Vibrations*; which will be equal to the *Beats* of the *Ballance*; therefore the *Beats* that shall be proposed in a *Minute* being given, to be 50; and it be demanded to give the *Length* of a *Pendulum*, The *Analogy* is,

As the Square of 50, viz. 2500
Is to the Square of 60, viz. 3600,
So is 39.2
To 56.4, the Length required: For,

As 2500 : 3600 :: 39. 2 : 56.4

And if the Length be given, to find the *Swings* or *Beats* in a *Minute*; The *Analogy* is,

As the *Altitude* given,
To the *Altitude* known,
So the *square* of the *Vibrations* known,
To the *square* of the *Vibrations* required,
The *square Root* whereof is the *Answer*.

And because the two middle *Terms* stand in all such *Questions*, and will be always 141120; therefore divide 141120, by the *square* of the *Swings* in a *minute*, it gives the length sought: or, by the length, it gives the *square* of the *Swings*.

And thus a *Swing* may be hang'd by any *Clock*, upon a Pin, so that it may freely *Vibrate* to Regulate the same Clock.

48)—4 (12
56— 7 (8
54 6 (9
21

The Numbers of the *Great Wheel* 56.
Its *Pinion* 4, turning the *Hour-wheel* 48.
The *great Wheel* turning a *Pinion* of 7, fixt to
The *Crown Wheel* 54, turning a *Pinion* of 6, fixt to
The *Ballance-wheel* 21.

The Quotients 8, 9, 21, and 2 Multiplyed into each other, produce 3024, Equal to the *Beats* in an hour: Because the *great wheel* turns once in an hour.

Other-

Otherwiſe 12, 8, 9, 21, 2, Multiplyed into each other, produce 36288.—— 12) 36288 (3024, and 60) 3024 (50.4 *Beats* in a *Minute*: And (as was ſhewed before) the *Length* of the *Pendulum* will be 55.5 Inches.

Fix a Weight upon a Wyre, running into a Rod, that ſhall have four Feet 7.5 Inches below the *Pin* whereon it plays; and about a Foot (or above) a Wyre beaten flat, with ſeveral holes to fit to the Top of this Rod; and to a *Pin* placed upon the *Ballance* towards the back-ſide, will regulate the *Motion* exceeding well.

For the Regulating the inequality of a *Swing*, when it may riſe ſometimes high, ſometimes lower: There are two ways, either by making the Line play betwixt two *Cheeks* of a *Cycloid*, as Monſieur *Hugens* hath directed, which may eaſily be effected to any Length of the *Pendulum*: Or elſe, by not ſuffering the *Pendulum* to *Vibrate* above an Inch from its ſettlement.

Monſieur *Hugens* in his Book of *Pendulum Clocks*, propoſeth a *Watch* about a *Mans height* to go 30 Hours, and to have theſe *Numbers*.

D B<br>
6——72<br>
*a* 30—30 *a*<br>
*a* 80—8—(10<br>
*E* 48 8—(6<br>
*I*—48——24(2<br>
O 15

The Great Wheel 80, &c. which turns about in an Hour, and ſhews Minutes; therefore for an Hour, Multiply the Quotients 10, 6, 2, 15, 2, and they will produce 3600, the Seconds in an Hour (60 in 60) is equal to 3600, or *Beats*. Now the Third Wheel I turn about in one Minute, for 10 in 6 is equal to 60, and carries a Plate divided into 60 Seconds, and ſhews the Seconds: And upon the Arbor of the Great Wheel, is fixed a Wheel, *a*, turning another Wheel *a*, both of 30 Teeth; and both turning about in an Hour; the latter has on it a Pinion *b* of 6 Teeth, turning *B* 72 in 12 Hours. This Watch hath a Pully tyed to its Weight, by which you may pull it up, and not ſtop the Watch. The Pendulum plays between two Cheeks, part of a *Cycloid*.

The next Queſtion (ſuppoſing there be a Screw below, or above the Pendulum, to lift it up, or let it down upon a Square Braſs Rule, divided into Inches and Tenth Parts) to know how many Minutes and Seconds every Tenth Part of an Inch will make the Watch go faſter or ſlower in a Day.

I take the Pendulum which ſwings Seconds, whoſe length is 39.2, And then by the Logarithms I make the following Table.

I.

| I. | II. | III. | IV. | V. |
|---|---|---|---|---|
| 38.7 | 1.587711 | 1.790988 | 60.39 | 9.21 |
| 38.6 | 1.588832 | 1.780378 | 60.31 | 7.26 |
| 38.9 | 1.589949 | 1.779819 | 60.23 | 5.31 |
| 39.0 | 1.591065 | 1.779261 | 60.15 | 3.36 |
| 39.1 | 1.592177 | 1.778705 | 60. 8 | 1.55 |
| 39.2 | 1.593286 | 1.778151 | 60. | 1.11 |
| 39.3 | 1.594393 | 1.777597 | 59.92 | 1.55 |
| 39.4 | 1.595496 | 1.777046 | 59.85 | 3.36 |
| 39.5 | 1.596597 | 1.776495 | 59.77 | 5.31 |
| 39.6 | 1.597695 | 1.775996 | 59.70 | 7.26 |
| 39.7 | 1.598790 | 1.775399 | 59.62 | 9.21 |

The firſt Column in the *Table*, has in the Middle the *Length* of the *Pendulum* 39.2 Inches: *Upwards* it diminiſheth one Tenth, and *downwards* increaſeth one Tenth.

The Second Column, are the Logarithms of the Firſt.

The Third Column, are half of the Logarithms of the difference of the II. taken out of the Logarithm 5.149588, which is, of the ſtanding Number 141120 aforeſaid.

The Fourth Column are the Numbers anſwering to the Logarithms in the III.

The Fifth Column are the *Minutes* and *Seconds* that thoſe *Augmentations* or *Diminiſhings* will cauſe in a Day; and are obtained by Multiplying 24 in 60, which makes 1920 equal to the Minutes in one Day, by the Decimals above or under 60''. which work may be eaſily done, for any length of a Pendulum.

## RULE IV.

### *Of finding out fit Numbers for the* Wheels *and* Pinions.

1. ANY two Fractions whoſe Terms are proportional perform the ſame Motion;

As $\frac{9}{1}$ $\frac{36}{4}$ $\frac{45}{5}$ $\frac{63}{7}$

The upper for the Wheel,
The lower for the Pinion.

2. If it be, As one Wheel, to one Pinion,
So is the Product of many Wheels,
To the Product of many Pinions: And both will perform the ſame Motion.

*Example.*

$$\text{So } \frac{1440}{28} \text{ is equal to } \frac{36}{28} \text{ in } \frac{8}{1} \text{ in } \frac{5}{1}$$

$$\text{And } \frac{36}{4} \text{ in } \frac{8}{7} \text{ in } \frac{50}{10} \text{ is equal to } \frac{14400}{280} \text{ equal to } \frac{1440}{28}$$

And it matters not in what Order the Wheels and Pinions are ſet, or which Pinion ſtands under every Wheel.

3. Theſe Factors 36 in 8, *i. e.* 288, may thus be varied, *viz.* Divide them by ſuch Numbers as will Meaſure them, and Multiply the Quotients by the Alternate Diviſors: The Product of theſe two laſt Numbers ſhall be two to the Product of the Factors given. For 36 in 8 is 288: Equal to 9 in 32, equal alſo to 288.

$$\begin{array}{cc} \text{—}\,9\,\text{—} & 8 \\ 38 & 8 \\ \frac{4}{32} & \frac{1}{9} \end{array}$$

4. If fit Numbers cannot be had by any of the Three former ways, you muſt ſeek ſome *Ratio*, as near as poſſible, in this manner.

As one of the two Numbers
Is to the other;
So is 360,
To a Fourth Number:

Divide this Fourth Number, and alſo 360, by 4, 5, 6, 7, 8, 9, 10, 12, 15, or which of them bringeth the *Quotient* neareſt to an *Intiger*— As if the two Numbers be 247 end 170, (which are too great to be cut into Wheels) and yet cannot be reduced into leſs, becauſe they have no greater Common Meaſure than Unity: Say therefore,

170 : 147 :: 360 : 3114 (5    311(52 (8
147 : 170 :: 360 : 4164      360(60
311(39 (8    360(45
360(45       416(52

Wherefore, For the two Numbers 147, and 170, you may take 52 and 60—39 and 45—45 aud 52.

## RULE V.

THe *Diameter*, or *Circumference* of any *Wheel* being given, in Inches and hundred parts of an Inch; and the Number of Teeth it is divided into; to give the Diameter, or Circumference of a Leſſer Wheel or Pinion, with a number of Teeth given, ſhall exactly agree with the Teeth of the Greater Wheel.

*Example.* The Great Wheel hath One Inch Diameter, and 50 Teeth: The Leſſer Wheel or Pinion 10 Teeth, ſay,

As 7 : 22 :: 1 : 3.14
And Again
As 50 : 3.14 :: 10 : 63 Ferè

For the Circumference of the P*inion*, whoſe Diameter will be .2 Tenths of an Inch.

RULE

## RULE VI.

TO give *Numbers* to a *Watch* that shall have a swift *Train*, about 20000 *Beats* in an *Hour*, that may have *Turns* about the *Fusie*, and go 16 Hours; and the Number of the *Crown Wheel* 17.

Say (by RULE II.)

As 12 : is to 16 :: So is 20000 : to 26666, the *Beats* for one turn of the *Fusie* : And because (by RULE I.) 26666 is equal to all the *Quotients* Multiplyed together into 17, and into 2, that *Number* being halv'd is 13333, and that again divided by 17, gives for the *Quotient* 784, which being broken into *Three Numbers*, which Multiplyed together, will be 784, or near to it; let them be 11, 9 and 8, which Multiplyed into each other, are 792 : Then 792 in 17 in 2, are equal to 26928, And then say,

As 16 : 12 :: 26928 : 20196, the *Beats* in one Hour. Also,

As 16 : 12 :: 12 : 9.

36

$\frac{9}{1}\times\frac{36}{2}$

36

4) 36 (9

5) 55 (11

5) 45 (9

5) 40 (8

17

2

Lastly, By these three *Quotients* assured 11, 9 and 8, find out the Three *Wheels* and *Pinions*, by taking the *Pinions* as you desire, as is done in the *Margine*. You may try several Experiments, to make the *Watch* go *Longer*, by altering the *Beats* and *Pinions* of *Report*.

EXAMPLE, Of a *Clock* or *Watch* proposed to go a *Week* (or *Eight Days*) with this *Order* : That the *Ballance Wheel*, or that which moves the *Pendulum*, may go about in a *Minute*, with an *Index* to shew *Seconds* : That the *Great Wheel* may go about in 12 *Hours* : And that the *Wheel* next it may go about in *One Hour* to shew *Minutes*.

First, Find how many *Seconds* there are in 12 *Hours*, by Multiplying 12 in 60, equal to 43200, and these are the *Beats* that shall be in one turn of the *Great Wheel*. These are double, because there are two *Swings* to one *Tooth* of the *Ballance Wheel*; The half of 43200 is 21600; Now the *Ballance Wheel* must needs be 30; Divide 21600 by 30, the *Quotient* will be 720, which is to be broke into Three *Quotients*, whereof the first must needs be 12 for the *Teeth* of the *Great Wheel*; Divide 720 by it, the *Quotient* is 60 for the two *Quotients* remaining, which may be either 10 and 6, or 5 and 12, or 8 and $7\frac{1}{2}$, which last let stand, and then the Work will stand as in the *Margine*, thus : And the *Pinions* to be taken as you please, to be all 8, the *Wheels* must be 96, 64, and 60; so then the great *Wheel* will go about in 12 hours; the *second Wheel* in an *Hour*, and the *Ballance Wheel* in a *Minute*, as was desired.

8) 96 (12

8) 64 (8

8) 60 ($7\frac{1}{2}$

30

10.140

8.128

8.120

72.

## RULE VII.

Of giving particular *Motion* to any *Movement*.

THe Number of a *Motion* is the proportion that it bears to one *Turn* of the *Hour Wheel*, or the *Pinion* of *Report*, from whither soever it be taken, which Proportion being broken into *Two* or *Three Quotients*, will ſhew the *Wheels* and *Pinions*, as if you took it for the *Beats* of the *Ballance*.

A NOTE Concerning *Time*. That which is ordinarily called *The Hour of the Day*: You are to conſider this in the length of *Days*, which are twofold, diſtinguiſhed only by the *Revolutions* of the *Earth* or *Sun*. The Firſt is the *Syderial Day*, where any fixt point or points of the *Earth* in the ſame *Meridian* or *Azimuth*, returns from any *Star* to the ſame again. The Second is the *Solar Day*, where the ſame Meridian of the *Earth* returns from the *Sun* to the ſame again: Neither of theſe two are the true *Equinoctial day*: Indeed, the *Syderial* is inſenſibly the ſame, if it be but for ſome ſmall ſpace of *Time*, the Difference being only ſome *Fourths* and *Fifths* of a *degree* ſlower in a *Day*; but the *Solar* is notably *Longer* than the other, *viz.* By 3 Minutes, 56 Seconds, 53 Thirds, 19 Fourths of *Time* in a *Day*; and from hence the Length of an *Hour* is generally accounted. Therefore to fit the *Pendulum* of a *Watch* or *Clock* to this *Solar Day* and Hour:

I. By the *Revolution* of a *Fixed Star* to the ſome point again, after one or more *Revolutions*, (which you muſt curiouſly *Obſerve* by fixing your Eye to a Point:) If the Motion for one *Revolution* want 3 Minutes 56 Seconds of 24 hours; or for Two 7 Minutes 43 Seconds; for Three 40 Minutes 39 Seconds, &c. Then doth your *Watch* or *Clock* go true to the *Equall* or *Middle Motion* of the Sun; if otherwiſe, the *Pendulum* muſt be altered to make it go ſo.

II. By a *Sun Dial*, which though it be made never ſo exact, and your *Motion* ſo too, yet there will be a conſiderable difference after ſome *Dayes*, nay, even in one *Day*: All which falls out by reaſon of the *Inequality* of *Natural Days*. And this inequality is now at laſt ſetled and demonſtrated by Mr. *William Flamſted*: A Table of his for this Equation for every Day in the year, I have here inſerted: And although it be not the very ſame every year, yet this (being for the year 1693) will ſufficiently ſerve for any other.

### *Of the following* TABLE of Equation of Time *and its Uſe*; *How hereby to Regulate a true made* Pendulnm Clock or VVatch, *ſhewing how much it ought to differ from the ſame* Sun Dial.

THe following *Table* ſhews the *Equation* of *Time* in *Minutes* and *Seconds* (as the Letters M *and* S, at the head of each *Column* denotes) for every day of the year, having theſe Words in the middle of each *Column*, *Watch too Faſt*, or *Watch too Slow*: And is of excellent Uſe, as appears by this which follows out of my loving friend Mr. *George Parker* in his *Engliſh Mercury* for the Year 1693.

Not-

Notwithſtanding, all perſons generally conclude, that the Sun by his Motion ſhews the *apparent time* of the *Day*, which is true, and that a *South* Sun always makes *Noon*, or 12 a *Clock*; yet this *Southing* of the Sun, or the ſpace of time from one Noon to the Next, is not equal, but longer or ſhorter, according to the *Suns* poſition in his *Elipſis*; ſo that it is impoſſible for any *Clock*, *Watch* or *Movement* whatſoever, to keep *Time* therewith. For this Reaſon, many perſons that are furniſhed with excellent *Movements* many times blame the Maker of them, when the *Errors* lie where they are not capable of diſcerning: For if a *Clock* truly *Rectified*, be ſet by the *Sun*, and kept going a Year, and at the Years end, agree exactly again with the *Sun*; yet in the interim, it would be found, at ſeveral times, to deviate conſiderably; and be ſometimes too *Faſt*, and at other times too *Slow*. The Reaſon of this *Difference* is: The *Clock* meaſures *Time equally*, but the *Sun unequally*; the Quantity of this *Difference* is, as before expreſt: As thus.

Admit on the firſt of *February* I would ſet a *Clock* to ſhew the *equal time* of the *Day*, I look in the following *Table* againſt *February* the *Firſt*, and there I find 14 Minutes, 48 Seconds, with the Words, *Watch too Faſt*, which informs me, that I muſt ſet my *Clock* ſo much faſter than the *Time* given by a *Sun-Dial*; and then, being kept going, it will by the Firſt of *March* be but 10 Minutes *too Faſt*; and on *April* the Third, the *Clock* and *Sun* will agree together exactly: Afterwards, the *Clock* will begin to be *Slower* than the *Sun*, as you may ſee by the *Table*.

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A

## A Table of Æquation of Time, for the Regulating of Pendulum Clocks or Watches.

| | January | | Febr. | | March | | April | | May | | June | | July | | August | | Sept. | | October | | Novem. | | Decem. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | M | S | M | S | M | S | M | S | M | S | M | S | M | S | M | S | M | S | M | S | M | S | M | S |
| 1 | 9 | 4 | 14 | 48 | 10 | 4 | 0 | W. too F. 45 | 4 | 10 | 1 | W. too Slow. 2 | 4 | 45 | 4 | 28 | 3 | 53 | 13 | 16 | 15 | 21 | 5 | 35 |
| 2 | 9 | 26 | 14 | 46 | 9 | 47 | 0 | 20 | 4 | 11 | 0 | 50 | 4 | 53 | 4 | 18 | 4 | 14 | 13 | 32 | 15 | 13 | 5 | 6 |
| 3 | 9 | 48 | 14 | 44 | 9 | 30 | 0 | 12 | 4 | 12 | 0 | 37 | 5 | 0 | 4 | 8 | 4 | 34 | 13 | 46 | 15 | 3 | 4 | Watch 38 |
| 4 | 10 | 10 | 14 | 41 | 9 | 13 | 0 | 3 | 4 | 13 | 0 | 23 | 5 | 7 | 3 | 57 | 4 | 55 | 13 | 59 | 14 | 53 | 4 | 9 |
| 5 | 10 | 31 | 14 | 37 | 8 | 55 | 0 | * 18 | 4 | 12 | 0 | 13 | 5 | 13 | 3 | 46 | 5 | 15 | 14 | 11 | 14 | 41 | 3 | 40 |
| 6 | 10 | 50 | 14 | 32 | 8 | 37 | 0 | Watch too 33 | 4 | 11 | 0 | * 0 | 5 | 18 | 3 | Watch too 37 | 5 | 36 | 14 | 23 | 14 | 29 | 3 | too Slow. 10 |
| 7 | 11 | 9 | 14 | 27 | 8 | 19 | 0 | 48 | 4 | 10 | 0 | 13 | 5 | 24 | 3 | 21 | 5 | 56 | 14 | 34 | 14 | 17 | 2 | 40 |
| 8 | 11 | 27 | 14 | 21 | 8 | Watch 1 | 1 | 2 | 4 | 8 | 0 | 26 | 5 | 29 | 3 | 8 | 6 | Watch 17 | 14 | 44 | 14 | Watch 3 | 2 | 10 |
| 9 | 11 | 45 | 14 | 15 | 7 | 43 | 1 | 16 | 4 | 6 | 0 | 39 | 5 | 33 | 2 | 55 | 6 | 38 | 14 | 54 | 13 | 49 | 1 | 40 |
| 10 | 12 | 2 | 14 | 7 | 7 | 25 | 1 | 28 | 4 | 3 | 0 | 52 | 5 | 36 | 2 | 46 | 6 | 58 | 15 | 4 | 13 | 34 | 1 | 11 |
| 11 | 12 | Watch too 18 | 13 | Watch too 59 | 7 | too Fast. 0 | 1 | Slow. 41 | 4 | Watch too 0 | 1 | 4 | 5 | Watch too 39 | 2 | Fast. 27 | 7 | too Slow. 19 | 15 | Watch too 13 | 13 | too Slow. 17 | 0 | 41 |
| 12 | 12 | 34 | 13 | 50 | 6 | 47 | 1 | 54 | 3 | 56 | 1 | 17 | 5 | 42 | 2 | 13 | 7 | 39 | 15 | 22 | 13 | 0 | 0 | 11 |
| 13 | 12 | 47 | 13 | 41 | 6 | 28 | 2 | 6 | 3 | 41 | 1 | Watch 30 | 5 | 44 | 1 | 58 | 7 | 59 | 15 | 28 | 12 | 43 | 0 | * 19 |
| 14 | 13 | 2 | 13 | 21 | 6 | 10 | 2 | 16 | 3 | 46 | 1 | 43 | 5 | 45 | 1 | 42 | 8 | 19 | 15 | 34 | 12 | 24 | 0 | 40 |
| 15 | 13 | 15 | 13 | 21 | 5 | 51 | 2 | 27 | 3 | 40 | 1 | 56 | 5 | 46 | 1 | 26 | 8 | 38 | 15 | 40 | 12 | 5 | 1 | 19 |
| 16 | 13 | Fast. 27 | 13 | Fast. 10 | 5 | 32 | 2 | 38 | 3 | Slow. 34 | 2 | too Fast. 8 | 5 | Fast. 46 | 1 | 9 | 8 | 58 | 15 | Slow. 45 | 11 | 45 | 1 | 49 |
| 17 | 13 | 38 | 12 | 59 | 5 | 14 | 2 | 48 | 3 | 28 | 2 | 20 | 5 | 45 | 0 | 52 | 9 | 18 | 15 | 50 | 11 | 25 | 2 | 18 |
| 18 | 13 | 48 | 12 | 47 | 4 | 55 | 2 | 55 | 3 | 21 | 2 | 32 | 5 | 44 | 0 | 35 | 9 | 37 | 15 | 53 | 11 | 4 | 2 | Watch 47 |
| 19 | 13 | 58 | 12 | 35 | 4 | 36 | 3 | 6 | 3 | 13 | 2 | 44 | 5 | 42 | 0 | 17 | 9 | 57 | 15 | 56 | 10 | 42 | 3 | 16 |
| 20 | 14 | 7 | 12 | 22 | 4 | 17 | 3 | 14 | 3 | 5 | 2 | 56 | 5 | 40 | 0 | * 1 | 10 | 16 | 15 | 58 | 10 | 26 | 3 | 45 |
| 21 | 14 | 15 | 12 | 8 | 3 | 58 | 3 | 22 | 2 | 56 | 3 | 7 | 5 | 38 | 0 | 18 | 10 | 34 | 15 | 59 | 9 | 56 | 4 | too Fast. 14 |
| 22 | 14 | 22 | 11 | 54 | 3 | 40 | 3 | 30 | 2 | 48 | 3 | 19 | 5 | 34 | 0 | 36 | 10 | 52 | 15 | 1 | 9 | 32 | 4 | 42 |
| 23 | 14 | 48 | 11 | 49 | 3 | 22 | 3 | 37 | 2 | 39 | 3 | 30 | 5 | 30 | 0 | Watch 55 | 11 | 19 | 16 | 0 | 9 | 8 | 5 | 9 |
| 24 | 14 | 34 | 11 | 24 | 3 | 3 | 3 | 43 | 2 | 29 | 3 | 41 | 5 | 26 | 1 | 14 | 11 | 28 | 15 | 59 | 8 | 43 | 5 | 36 |
| 25 | 14 | 38 | 11 | 9 | 2 | 45 | 3 | 39 | 2 | 19 | 3 | 51 | 5 | 20 | 1 | 34 | 11 | 45 | 15 | 57 | 8 | 17 | 6 | 4 |
| 26 | 14 | 42 | 10 | 51 | 2 | 26 | 3 | 53 | 2 | 9 | 4 | 1 | 5 | 14 | 1 | too Slow. 53 | 12 | 2 | 15 | 55 | 7 | 51 | 6 | 30 |
| 27 | 14 | 45 | 10 | 38 | 2 | 9 | 3 | 57 | 1 | 59 | 4 | 11 | 5 | 8 | 2 | 12 | 12 | 18 | 15 | 51 | 7 | 23 | 6 | 57 |
| 28 | 14 | 47 | 10 | 21 | 1 | 51 | 4 | 1 | 1 | 48 | 4 | 20 | 5 | 2 | 2 | 32 | 12 | 33 | 15 | 47 | 6 | 59 | 7 | 23 |
| 29 | 14 | 48 | | | 1 | 34 | 4 | 4 | 1 | 37 | 4 | 29 | 4 | 54 | 2 | 52 | 12 | 49 | 15 | 41 | 6 | 31 | 7 | 48 |
| 30 | 14 | 49 | | | 1 | 17 | 4 | 7 | 1 | 25 | 4 | 37 | 4 | 46 | 3 | 13 | 13 | 4 | 15 | 35 | 6 | 3 | 8 | 12 |
| 31 | 14 | 49 | | | 1 | 1 | | | 1 | 14 | | | 4 | 37 | 3 | 33 | | | 15 | 27 | | | 8 | 35 |

Thus

Thus by knowing the *Equal Time*, you may at any time (by help of this *Table*) know the *True* or *Apparent Time*: For, Look against the *Day* of any *Month*, and find the *Æquation*, which if it be *Watch too fast*; then substract that Days *Æquation* from the *time* given by the *Clock*, and it will be the *Apparent Time*: And if it be *Watch too slow*, then, contrarily, Add the *Æquation* to the *Time* signified by the *Clock*, and you have your desire.

But in the right managing of a *Clock* or *Watch*, it ought, always, to be examined by the same *Sun-Dial* it was *set by*, and at, or near, the *Hour* too, for there is often difference in *Sun-Dials*: And withal, not to Set the *Clock* by the *Sun* early in the *Morning*, or late in the *Afternoon*; for then the shadow on the *Dial* is not the true *Time* of the *Day*, in regard the *Sun* hath then considerable *Refraction*, which makes the *Sun* appear higher in *Altitude* than really he is, and the nearer the *Horizon* the *Greater*; So that the *Time* given by the *Sun* is *later* in the *Morning* then truth, and the contrary in the *Afternoon*. Therefore, To observe the true *Time* of the *Day*, let it be always near *Noon*, if it be a *South*, or an *Horizontal Dial* that you make use of: But if it be a *Quadrant* or other *Instrumental Dial*, which give the *Hour* by dependance on the *Sun's Altitude*, it ought to be done with great nisity, and never after *Ten* in the *Forenoon*, nor before *Two* in the *Afternoon*; in regard the *Sun* between the Hours of 10 and 2, varies not much in *Altitude*.

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CHAP.

# RECREATIONS
# Hiſtorical.

## *Of the Meaſures, and Proportions of the Members of Man's Body.*

### Proœme.

MAN (ſaith the Philoſopher) is the *Meaſure* of all things: *Firſt*, Becauſe he is the moſt *perfect Body*.

*Secondly*, For that (in effect) our uſual *Meaſures*, have taken their *denominations* from *Humane Bodies*, As the *Foot*, the *Inch*, the *Cubit*, the *Pace*, &c.

*Thirdly*, Becauſe the Symetry, and Concordancy of the *Parts* of *Man's Body* is ſo admirable; That all *Magnificent Buildings*, as of *Temples*, *Columns*, &c. are in ſome Meaſure, Faſhioned and Compoſed after *Man's Proportion*.

*Fourthly*, For that *Architects* do reſemble the ſeveral *Members* of a *Corinthean* and other Columns, to the *Members* of *Mens Bodies*: As *Vitruvius* in his Third Book: And *Albertus Durens* hath writ a whole Book of the *Meaſures* of *Man's Body*, from *Head* to *Foot*; of which ſome follow:

1. The *Height* of *Man*, is equal to the diſtance, from one end of the *Middle Finger* to the *other*, the *Arms* being extended to their full length.

2. If the *Legs* and *Arms* of a *Man*, be extended *Salteir* wiſe, or as it is uſually termed making a St. *Andrew's Croſs*; If one foot of a pair of *Compaſſes* were placed upon the *Navel* of the *Belly*, and the other turned about, it would juſtly touch the *Toes* and *Fingers* of the *Man* ſo extended.

3. The breadth of a *Man* from one ſide to the other, the *Breaſt*, the *Head*, and the *Neck*, make the ſixth part of all the Body.

4. The *Length* of the *Face* and *Hand* are equal.

5. The *Thickneſs* of the *Body*, taken from the *Belly* to the *Back*, is the *Ninth* part of the whole Body.

6. The length of the *Brow*, the length of the *Noſe*, the ſpace between the *Noſe* and the *Chin*, the length of the *Ears*, the greatneſs of the *Thumb*; are all of them equal one to the other.

But

But besides these Symetries of the *Members* of *Mens Bodies*, I will here insert,

*The* Description *and* Measures *of all the Principal* Parts *of* Mans Body, *as they are set down by* Leon Baptista Alberti, *Reduced to all our* English Measures; *In* Feet, *and Hundred parts of a* Foot.

| The height from the Ground to the | F. | 100 Parts |
|---|---|---|
| The *Instep* of the *Foot*, | 0 | 30 |
| *Ankle-Bone*, on the out-side of the *Leg*, | 0 | 22 |
| *Ankle-Bone*, on the in-side of the *Leg*, | 0 | 31 |
| *Recess* which is under the *Calf of the Leg*, | 0 | 85 |
| *Recess* which is under the *Relieve* of the *Knee-Bone* within, | 1 | 43 |
| *Muscle* on the out-side of the *Knee*, | 1 | 70 |
| *Buttocks* and *Testicles*, | 2 | 69 |
| *Os-Sacrum*, | 3 | 00 |
| *Joynt* of the *Hips*, | 3 | 11 |
| *Navel*, | 3 | 60 |
| *Wast*, | 3 | 79 |
| *Tets*, and *Blade-Bone* of the *Stomach*, | 4 | 35 |
| Part of the *Throat* where the *Weezle Pipe* beginneth, | 5 | 00 |
| *Knot* of the *Neck*, where the *Head* is set on, | 5 | 10 |
| *Chin*, | 5 | 20 |
| *Ear*, | 5 | 50 |
| *Roots* of the *Hairs* in the *Forehead*, | 5 | 90 |
| *Middle Finger* of a *Hand* that hangs down, | 2 | 30 |
| *Joynt* of the *Wrist* of the said *Hand*, | 3 | 00 |
| *Joynt* of the *Elbow* of the said *Hand*, | 3 | 35 |
| Highest Angle of the *Shoulder*, | 5 | 18 |

*The* Amplitude *or* Largeness *of the* Parts, *and* Measures *from the* Right-hand *to the* Left.

| The | | |
|---|---|---|
| Greatest breadth of the *Foot*, | 0 | 42 |
| Greatest breadth of the *Heel*, | 0 | 23 |
| Breadth of the fullest part beneath the jettings out of the *Ankle-Bones*, | 0 | 24 |
| *Recess*, or faling in above the *Ankles*, | 0 | 15 |
| *Recess* of the *Mid Leg*, under the *Muscle* or *Calf*, | 0 | 25 |
| Greatest thickness of the *Calf*, | 0 | 35 |
| Falling in under the *Relieve* of the *Knee Bone*, | 0 | 35 |
| Greatest breadth of the *Knee-Bone*, | 0 | 40 |
| Falling in of the *Thigh*, above the *Knee*, | 0 | 35 |
| Breadth of the middle or biggest part of the *Thigh*, | 0 | 35 |
| Greatest breadth among the *Muscles* in the joynt of the *Thigh*, | 1 | 11 |
| Greatest breadth between the two *Flanks*, above the Joynts of the *Thigh*, | 0 | 00 |
| Breadth of the largest part of the *Breast*, beneath the *Arm-Pits*, | 1 | 15 |

| | | F. | 100 Parts |
|---|---|---|---|
| The | Breadth of the largest part between the *Shoulders*, | 1 | 50 |
| | Beneath the *Neck*, | 0 | 00 |
| | Breadth between the *Cheeks*, | 0 | 48 |
| | Breadth of the *Palm* of the *Hand*, | 0 | 00 |

*The* Breadth *and* Thickness *of the* Arms, *differ according to the several motions thereof; but the most common are these following:*

| | | | |
|---|---|---|---|
| The | Breadth of the *Arm* at the *Wrist*, | 0 | 23 |
| | Breadth of the *Brawny* part of the *Arm*, under the *Elbow*, | 0 | 32 |
| | Breadth of the *Brawny* part of the *Arm* above, between the *Elbow* and the *Shoulder*, | 0 | 40 |

*The* Thickness *from the* Fore-part *to the* Hinder-part.

| | | |
|---|---|---|
| The Length from the *Great Toe*, to the *Heel*, | 1 | 00 |
| The Thickness from the *Instep*, to the *Angle* or Corner of the *Heel*, | 0 | 43 |
| The Falling in of the *Instep*, | 0 | 30 |
| From the falling in under the *Calf*, to the middle of the *Shin*, | 0 | 36 |
| The out-side of the *Calf* of the *Leg*, | 0 | 40 |
| The out-side of the *Pan* of the *Knee*, | 0 | 40 |
| The thickness of the biggest part of the *Thigh*, | 0 | 60 |
| From the *Genitals* to the highest Rising of the *Buttocks*, | 0 | 75 |
| From the *Navel* to the *Reins*, | 0 | 70 |
| The thickness of the *Waste*, | 0 | 66 |
| From the *Teats*, to the highest rising of the *Reins* of the *Back*, | 0 | 73 |
| From the *VVheezle-pipe*, to the *knot* or *joynture* of the *Neck*, | 0 | 40 |
| From the *Forehead*, to the hinder part of the *Head*, | 0 | 64 |
| From the *Forehead* to the *hole* of the *Ear*, | 0 | 00 |
| The thickness of the *Arm* at the *Wrist*, | 0 | 00 |
| The thickness of the *Brawn* of the *Arm* under the *Elbow*, | 0 | 00 |
| The thickness of the *Brawn* of the *Arm*, between the *Elbow* and the *Shoulder*, | 0 | 00 |
| The greatest thickness of the *Hand*, | 0 | 00 |
| The thickness of the *Shoulders*, | 0 | 34 |

By means of these Measures it may easily be computed what proportions all the parts and Members of the Body, have one by one to the whole Length of the Body; and what Agreement and Symetry they have among themselves; as also how they vary or differ one from another; which things are most fit to be known to *Painters* and *Carvers* especially: Nor were it from the purpose to particularise how the *Parts* vary and alter, according to the several gestures incident to humane *Bodies*, as, whither they be *sitting*, or *inclining* to this or that *side*. But we shall leave the more curious disquisition into these things, to the diligence and industry of our *Artist*.

CHAP.

# CHAP. I.

## *Of* Men *or* Giants, *of Prodigious Statures.*

HAving (before in this Book) given you a perfect account of the Dimensions of *Mans Body*, according to every Part and *Member* thereof, that is, of such a Body as the generality of *Men* and *Women* are, not extraordinary *Tall*, *Thick*, or *Dwarfish*, but of a middle and comely Stature; I shall now give account of some *Monstrous Giants*, which *History* makes mention of:

1. We read in the 3d *Chapter* of *Deutrinomy*, of a *Giant* called *Ogge*, of the Town of *Rabath*; who had a *Bed* of *Iron* which was Nine Cubits long, and Four Cubits broad.

2. In the 17th *Chapter* of the 1st Book of the *Kings*, there is mention of *Goliah*, whose height was a *Palm* of six Inches, which is more than Nine of our *English* Feet; He was Armed from Head to Foot, whose *Curnat*, *Launce* and other *Armor* which he wore, did Weigh, of our *Weight*, at the least 500 *l.*

3. In the time of the *Grecian* Wars, after a great overflowing of the *Rivers*, *Salinus* reports, That there was found upon the Sands the *Carcase* of a *Man*, whose *length* was 33 *Cubits*; (which in our measure is 49 Foot and a half) a prodigious Carcase! For (according to the foregoing Proportions) his *Face* should be *five Foot* in length.

4. *Pliny* reports, That after an *Earthquake*, a Mountain being cleaven thereby, in it was found a *Body* standing upright, which was 46 Cubits high; some report it to be the Body of *Orion*, but whose Body soever it was, it must be Monstrous; for what can be thought of a *Hand* to be seven Foot, and his *Nose* two Foot and a half long.

5. *Plutarch* reports, in the Life of *Seutorius*, That in *Timgy*, a Marative Town; That because *Seutorious* could not believe what he had heard reported, caused a *Sepulchre* to be opened, and found a *Body* therein which contained 60 Cubits in *Length*; according to which proportion, he should be 15 of our Feet in *Breadth*, his *Face* 9 Foot long, his *Thumb* 3 Foot; which is neer as big as the *Collossus* at *Rhodes*.

6. It is reported by *Symphoris Campesius*, That at the foot of a Mountain near *Trepane*, in opening the foundation of a House, they found a *Cave* in which was found a *Giant*; which held in his hand a great *Post*, like the *Mast* of a *Ship*; and handling it, it moldred all into Dust, except the *Bones* which remained, and were of so vast a bigness, that the *Head* would hold 5 Quarters of Corn; by which proportion, his *Length* should be 300 Foot, the length of his Face 30 *Foot*, and his *Nose* 10 Foot.

7. *Josephus Ancosta*, in his *Italivn History* reports, That at *Peru* was found the *Bones* of a *Giant* 18 Foot high: And other Histories are full of the Description of *Giants* of 9, 10 and 12 Foot high.

8. In the 58 *Olympiad*, by the admonition of the *Oracle*, the Body of *Oreftes* was formed at *Tegaa* by the *Spartans*, and we underftand (faith *Solinus*) that the juft length of it was 7 Cubits, that is, of our Meafure 10 Foot and a half.

9. In the Senate Houfe at *Lucerne*, in the year 1584, I was fhewed (faith my Author *) the fragments of fome Bones of a prodigious greatnefs; They were found in a Cave near the Monaftery of *Reiden*, under an old Oak which the Wind had then blown down: When I had confidered them (faith he) though they were wafted, fpunged, and light, I obferved that they anfwered (though the Skull was not there) to the Body of a Man, and wrote upon each of them what they were, as the loweft Bone of the Thumb, a Cheek Tooth, the Shoulder-Blades, a Heel bone, and many others, all which differed nothing from the Bones of a humane Body. Thefe Bones I compared with a Skeleton of my own, and caufed an entire Skeleton to be drawn of fuch greatnefs, as all thefe Bones would have made, if they had been whole and together; and it amounted to full 19 Foot in height.

* *Plat. obf. Med. l. 3. p. 4, 585.*

10. *Walter Parfons* an *Englifh-man*, born in *Staffordfhire*, he was put Apprentice to a Smith, and grew fo tall, that a hole was made for him in the ground to ftand in up to the Knees, to make him adequate to his fellow Workmen: He was afterwards Porter to K. *James* the Firft. He would make nothing to take two of the talleft Yeomen of the Guard (like the Gizard and Liver) under his Arms at once, and order them as he pleafed.

11. *William Evans* born in *Monmouthfhire*, and may juftly be countthe Giant of our Age, for he was full 7 Foot and a half in height: He was Porter to King *Charles* the firft, and fucceeded *William Parfons* in his Place, and exceeded him in the height two Inches; but not fo proportionable in all the parts of his Body as *Parfons* was.

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# CHAP. II.

## *Of* Dwarfs *and* Pigmies; *or* Men *and* Women *of lower then ordinary ftature.*

1. JUlia, the Neice of *Auguftus*, had a little Dwarfifh Fellow called *Canopus*, whom fhe much efteemed, he was not above 2 foot and 5 inches in height; and *Andromeda*, a freed *Maid* of *Julia*, was of the fame height.

2. Two Gentlemen, both Knights of *Rome*, as *Marcus Varro* reporteth, *viz. Marius Maximus* and *Marcus Tullius*, were either of them but 2 Cubits high, that is 3 foot.

3. *Nicephorus* in his Ecclefiaftical Hiftory, faith, I faw one *John de Eftrix* of *Mechlen*, when he was brought through *Bafil* to the Duke of *Parma*, then in *Flanders*, *Anno* 1592; He was 35 years of Age, he had a long Beard, was perfect and ftreight in all his Limbs, and was but 3 foot high; he could not go up Stairs, much lefs could he get upon a

Form, but was always lift up by a Servant: He was skilled in Three Tongues, ingenious and industrious, and with him (a while) I played at Tables.

4. There was a Dwarf at *Wartemberg*, at the *Nuptials* of the Duke of *Bavaria*: He was Armed Cap-a-Pee, Girt with a short Sword, and a short Spear in his hand; He was put into a Pie, which was set upon the Table, at last, raising the Lid, he stepped out, drew his sword, and after the manner of a Fencer, traversed about the Table.

5. *Marcus Antonius* had one *Sisyphus* a Dwarf, of a vivid wit, and yet was not full Two foot high.

6. I saw (saith my Author*) in the year 1610, one *John Ducker*, an *English* Man, (whose Picture I have by me, drawn at full length) he was about 40 years of Age; he had a long Beard, and was only 2 foot and a half high; of streight and thick Limbs, and well proportioned. *Plater. Obs. Lib. 3. p. 582.

7. *Augustus Cæsar* exhibited in his Plays one *Lucius*, a Young Man; he was not full 2 foot high; and (saith *Ravisius*) he weighed not full 17 Pounds; and yet he had a great and strong Voice.

8. *Chiracus* was a man of exceeding small stature, yet was he the Wisest Councellor that was about *Saladine*, that great Conqueror of the *East*.

9. In the year 1305 *Uladislaus Cabitalis* (called the *Pigmy* King of *Poland*) Reigned, and Fought more Battles, and obtained more glorious Victories therein, than any of his Long Shanked Predecessors. [*Vertue refuseth no Stature*] But, commonly, Vast Bodies, and extraordinary Statures, have dull, sottish and leaden Spirits.

10. *Cardan* reports, That he saw a Man in *Italy*, at full Age, not above a foot and half high carryed about in a Parrots Cage.

11. There was a *French* Man, of the Country of *Lamosin*, of about the same height, with a formal Beard, who was shewn in a Cage for Money, at the end whereof was a little Hutch into which he retired; and when the Assembly was full, he would come out and play upon an Instrument.

## CHAP. III.

### *Of Monsters, and other Persons, as have made entrance into the World in a different manner from the rest of Mankind.*

I. BUcanon relates of a Monster which had only one Body below the Navel, but above, two different ones; when any part below the Navel was hurt, both the Bodies above participated of the Pain; if above, that Body only felt it that was hurt. These two upper Bodies would sometimes quarrel, and one Dying, the other Pined away by degrees: It lived 28 years, and could speak several Languages, and was taught to play on a Musical Instrument.

II. In

II. In the year 1538. there was Born one who grew up to the Stature of a Man; he was double as to his Head and Shoulders, so that one Face stood opposite to the other: Both were of a likeness, resembling each other both in Beard and Eyes: They had both the same Appetite, and both Hungred alike: The Voyce of both was almost the same; and both Loved the same Wife.

III. *Johannes Naborowsky*, a Noble *Polonian*, had seen in his Country of *Basil*, two little Fishes without Scales, which were brought forth by a Woman, and as soon as they came out of her Womb, did Swim in Water as other Fishes.

IV. Not long since in *Elsingorn* lived a Woman of good quality, who by her account drew near to the time of her delivery, and so provided all things necessary: But in her last Month, her big Belly seemed to be much fallen. Her time of Travel being come, and the usual Pains of Labour going before, she was delivered of a Creature very like unto a Dormouse of the greater size, which (to the amasement of the Women then present) with great celerity sought out, and found a hole in the Chamber into which it crept, and was never seen after.

V. In the year of our Lord 1639, at *Norway* we read of a marvelous Example of a Woman, who having often before been delivered of Humane Births; and again Big, and after strong labour was delivered of Two Eggs: This Womans name was *Anna*, the daughter of *Amundus*, and Wife to *Gudbrandus Erlandsonius*, who already had been Mother of Eleven Children. This *Anna*, in the year 1639, *Apr.* 17. and in the Evening of the same day, was delivered of an Egg, in all respects like that of a Hen, which being broken by the Women then present, they found that in the Yolk and White thereof there was no difference, but answered directly to a common Egg. Upon the 18th day of *April.* about noon, in the presence of the same persons, she was delivered of another Egg, in all respects like the former. This second Egg was sent to Dr. *Olaus Wormius*, to the University, in whose Study it is reserved to be seen of such as shall desire it.

VI. In the year of our Lord 1576, upon the 27th day of *December*, One *Ann Tromperin* about 30 years of Age, was delivered of a Boy and two Serpents. This Woman (saith *Caspar Banbinus*, in his History of *France*) told me upon her faith, that in the summer before, in an extream hot day she had drunk of a Spring in the Grove called *Brudetholk*, adjoyning to *Basil*, where she suspected that she had drank of the sperm of Serpents; she grew so big, that she was fain to carry her Belly in a Swathling-band The Child was very Lean, the Serpents were each of them an Ell in length, and thick as the Arm of an Infant, both which, alive as they were, buried by the Midwife in the Church-Yard of St. *Elizabeth*.

VII. The Concubine of Pope *Nicholas* the third was delivered of a Monster which resembled a Bear. *Mertin* the 4th, his successor, entertained the same Lady, and fearing that she should bring forth other Bear-whelps; he caused all the Painted or Carved Bears about his Palace to be

be expunged or removed: For this Pope was not ignorant how the ſhapes and Pictures which are conceived in a Womans imagination at the time of conception, do remain imprinted in the Body of that which is conceived.

VIII. At *Tertoghenboſch*, a City in *Brabant*, upon a ſolemn Feſtival, ſome of the *Citizens* diſguiſed themſelves inſeveral habits, ſome like Angels, ſome like Devils, to augment the ſport. One of theſe (who acted a Devils part, ran home to his houſe in his Devils ſhape, took his Wife, threw her upon a Bed, ſaying, he would get a young Devil upon her; he was not deceived; for of that copulation, there was born a Child, ſuch as the wicked Spirit is Painted, which at his coming into the World, began to run and skip up and down the Chamber.

IX. In the Little Town of *Quiero*, amongſt the *Subalpines*, upon the 17th day of *January* 1578, An honeſt Matron was there delivered of a Child which had upon its head 5 horns, like to thoſe of a *Ram*: From the upper part of his Forehead there hung backwards a long piece of Fleſh, that covered moſt part of its Back, in form like a Womans Headlace: About its Neck was a double row of Fleſh like the Collar of a Horſe. At the ends of its Fingers were Claws, like to thoſe Tallons of Birds of Prey. Its Knees were in the hinder parts of its Legs: Its Right Leg and Foot were of a ſhining Red Colour; and the reſt of its Body all Swarthy: It came into the World with ſuch a great Cry, that it affrighted the Midwife and the reſt of the Women there preſent—This Monſter was ſent for by *Subalpinus* to his Court to be ſeen of him and his Courtiers.

X. In *Leſina*, the biggeſt *Iſland* in the *Adriatick Sea*, there was born a Monſter: Below the middle part whereof, there was but one Body; and above the middle there were Two Living Souls; each ſeparated from the other, with ſeveral Members; their Heads being both of one bigneſs, but different in *Phiſiognomy*: The Belly of the one joyned to the poſterior parts of the other; and their Faces looked both one way, as if the one had carried the other on his Back; for he that was behind would often lay his hands about the Neck of the other. Their Eyes were exceeding big, and their Hands, Thighs and Legs greater than thoſe of an Infant of three times their age, which was but 36 days: The Excrements of both iſſued forth at the ſame place: Their Feet were round and cloven, like thoſe of a Camel: They received their Food with an inſatiable deſire, and continually mourn'd with a pitiful noiſe: When one Slept the other waked: The Mother bought that Birth with the loſs of her life, and the Monſters died ſoon after. This was ſhewn to *Lithgoe* in his Travels by a *Venetian*, the Governour of that *Iſland*.

XI. When *Fulvius Flaccus* was Conſul, there was born in *Rome* of a Maid Servant, a Monſter: It had Four Feet, Four hands, Four Eyes, Four Ears, and Two Members of virility.

XII. A Woman in *Prague* being with child was cauſed to hold a Calf while it was kill'd, and ſtanding by while it was opened, at the falling of the Bowels ſhe felt a commotion within her; and ſoon after

was

was delivered of a Boy, whose Liver, Inteſtines, Stomach and Spleen, with the greateſt part of the Meſentery hung out beyond the Navel. It lived but a few Hours.

XIII. At *Cracovia*, (ſaith *Lycoſthines*) in the year 1543, there was born of Noble Parents, a *Monſter* with Flaming and Shining Eyes; the Mouth and Noſtrils were like thoſe of an Ox, it had long Horns, and a Back hairy like a Dogs: It had the Faces of Apes in the Breaſt where the Tets ſhould ſtand: It had the heads of Dogs upon the two Elbows, and at the whir'l-bones of each Knee looking forward: It was Splay footed and Handed: The Feet were like Swans Feet: It had a Tail turned upwards, that was crooked backwards, and about half an Ell Long. It lived but Four hours from the birth of it; and neer its death it uttered theſe Words; *Watch, For the Lord your God comes.*

XIV. At St. *Lawrence* in the *Weſt Indies* in the year 1573, there was a Monſter born, Which (beſides the horrible deformity of its Mouth, Ears and Noſe; had two horns on the head, like thoſe of young Goats; long hair on the body; a fleſhy Girdle about the middle, double; from whence hung a piece of Fleſh like a Purſe, and a Bell of Fleſh in his left hand like thoſe the *Indians* uſe when they dance; White Boots of Fleſh on his Legs doubled down. In brief (ſaith my Author, Dr. *Henry Moor*, in his Immortality of the Soul, P. 173.) The whole Shape was horrid and diabolical; and conceived to proceed from ſome Fright the mother had taken from the Antick Dances of the *Indians*; amongſt whom the Devil himſelf does not fail, ſometimes, to appear.

XV. Upon the 17th of *October* 1637, At *Boſton* in New *England*, one Miſtreſs *Dyer* was delivered of a Monſter which had no head; the Face was on the Breaſt; the Ears like Apes, grew upon the Shoulders; the Eyes and Mouth ſtood far out; the Noſe hooking upwards; the Breaſt and Back full of Prickles; the Navel and Belly where the Hyps ſhould have been; inſtead of Toes, on each foot it had three Claws; upon the Back it had two great holes like Mouths; above the Eyes it had Four horns; It was of the Feminine Sex. The Father and Mother of this Monſter were both great Familiſts, ſaith my Author, *Clark's Miror*, pag. 249.

*As there have been ſeveral Monſters brought into the World; So alſo have there been brought perſons into the World (although not Monſtrous, yet) in a different manner from the generality of mankind.*

XVI. *Zoroaſtres* Laughed the ſame day he was born; his Brain alſo did ſo evidently pant and beat, that it would bear up the hands of thoſe that laid them upon his head: An evident preſage (ſaith *Plato*) of the great Learning he at length attained unto.

XVII. *Nero Cæſar*, the Emperour, came into the World with his Feet formoſt: Who all the time of his Reign was a very enemy to mankind.

XVIII. Some Children are brought into the World with Teeth in their heads; As M. *Curius*, and *On Papyrius Carbo*; both of them great men and honourable Perſonages.

XIX. Some

XIX. Some are cut out of their Mothers Wombs; As *Scipio Affricanus* the first, *Julius Cæsar*, *Manillius*, *Macduff* Earl of Fife, And *Edward* the Sixth of *England*.

XX. In the year 959. *Buchardus* Earl of *Limsgow*, *Beuchorn*, *Montfort*, and *Abbot* of *Sangal*, was vulgarly called Unborn, because he was cut out of his Mothers Womb.

XXI. One *Cornelius Gemma*, *a German*, says, that himself had cut out of the Wombs of Six several Women, Six living Children.

XXII. *Pliny* in his Natural History, speaks of a Child in *Sagnotum* (in that year it was sacked by *Hanibal*) which so soon as it was come out of the Mothers Womb, presently returned into it again.

XXIII. *Johannes Dubravius* relates of *Lewis* the Second King of *Hungary* and *Bohemia*, that there were Four things in him remarkable for haste, *viz.* (1) That he became Great in a short time: (2) That he had a Beard too soon: (3) That he had White hares before he was 17 years of Age: And (4) That he was born into the World without any of that Skin which they call *Epidermis*: He died *Anno* 1526. in the 29*th* year of his Age.

XXIV. When *Spinola* Besieged the City of *Bergopsonna*, a Woman near her time of Travel went out to draw water, at which time she was taken off in the middle by a Cannon Bullet; so that the lower part of of her fell into the Water; such as were by, ran to her, and saw there a Child moving it self in the Bowels of the Mother: They drew it forth, and soon after brought it to *Antwerp*, where the *Infanta Isabella*, caused it to be Baptized; and gave it the name of *Albertus Ambrosius*, One of her Fathers Captains.

XXV. *Enecho Arista*, the first King of *Navar* being dead, *Garsias* his Son succeeded, who being one day in the Village of *Larumbe*, was surprised by some *Moorish* Robbers, assaulted and slain: they Wounded *Urracha* his Queen in the Belly with a *Launce*: The Thieves put to flight, the Queen at the Wound was delivered of a Son and dyed; the Child was safe, and was named *Sancius Garsia*: He was well educated, proved a Valliant Man, and succeeded his Father in the Kingdom.

XXVI. The Wife of one *Simon Kneuter* of *Wessemberg* went with Child to the ninth Month, and then falling into Travel she dyed Undelivered; those that were by doubted not but that the Child was dead also; they disposed of the Mother as is usual; but some few hours after, they heard a Cry; they ran, and then found the Mother dead indeed, but delivered of a Daughter, that was in good health, and lay at her feet. *Salmuth* saith that he hath seen Three several Women, who have been dead in Travel; and yet, after Death, delivered of the Children they went with.

*To conclude these two last Paragraphs, I shall give an instance in one Person participating of both,* viz.

XXVII. There never was in any man a greater uniformity of Body and Mind (saith my Author Sir *Rich. Baker*) than there was in *Richard* the Third, King of *England*, for both of them were equally deformed—Of Body he was but Low, *Crook Back'd* and *Hook-Shouldred*; *Splay-Footed* and *Goggle Ey'd*; His face Little and Round; his *Complexion* Swarthy; His left Arm (from his Birth) Dry and Withered—He was born a Monster in Nature, having all his Teeth, Hair on his head, and Nails on his Fingers and Toes. And just such were the qualities of his Mind.

XXVIII. *Offa*, the Son of *Wasmond*, King of the *West Saxons*, was Tall of Stature, and of a good constitution of Body. He was Blind till Seven years of Age, and then could See: He was also Dumb till Thirty years of Age, and then spake.

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## CHAP. IV.

### *Of the length of Age which men lived in former times, shortly after the Creation, and of others of later date.*

IT hath been a *Question*, what manner of *Years* those were, our Fore-Fathers are said to have lived, as 700, 800, and 900 years, as *Methusala*, since years have been taken diversly. Some have imagined they could not be our *Anni Solares*, as we account our years, as being a thing incredible, that the date of a mans life should extend it self to that length, far beyond the Age of the eldest Oake. Some account (as *Pliny* reporteth) every *Summer a Year*, and *Winter* another: As also the *Arcadians* counted their year by Three Months; others again by the course of the *Moon*, as the *Egyptians*; so some of them are reported to have lived 1000 years. There are those therefore that imagine those years mentioned *Gen.* V. To be understood to consist of 36 days, Ten whereof make but one *Salar year*, hereby reckoning that who are in the Scripture said to have lived 900 years, lived of our years but 90, every hundred of those Monthly years amounting but to Ten of ours. So they believed all that space of time which is contained in one year to have been anciently divided into Ten parts, and every part taken for a year, and every one of these ten parts to have had *Senarium quadratum*, because in Six days God finished his Work of the Creation; all which number multiplyed by Ten, make just 12 Months. But these conclusions fall out to be most absurd, for if we consider what will follow thereupon, *Caman*, who begat children when he was 70 years of age, should have begotten them when he was but Seven: Besides, if we make a year but of 36 days, of what length must the Month be? Surely no more then Three days: And then, How can that place in *Gen.* VII. 11. Where it is said, *The Flood began the 27th day of the Second Month*? And how will it agree where it is said, *Gen.* VIII. 4. *The Ark rested upon the Mountains of Ararat the 27th day of the second Month*?

Let

Let us therefore certainly believe the years then to have been all one with ours, and that which is spoken of the great Age of those Fathers, not much to differ from the computation of our years. For, it is again said, *Gen.* 8. 5. That *The Mountains appeared upon the first day of the Tenth Month*; wherefore the Year consisted of many Months: And that we may not think the Month consisted but of Three days, observe, the Twenty seventh day is mentioned.

Now, If you would know the Reason, why the Fathers then lived so long, know that there are Two Causes; First, the *Final*; Secondly, the *Efficient*.

The *Final* Causes were, (1.) Increasing the World with People, whereby it might be replenished, which they could not do but by living a long time. (2.) Arts were to be invented, for they are not found but by long experience. (3.) The Worship of God was to be delivered by Tradition; for, as yet, the Written Word was not: But that could not be in such a variety of People, except those who received it from God had not been long liv'd.

The *Efficient* Causes of their length of Life were, (1.) The singular Blessings of God mentioned, *Gen.* 30.20. *I am thy Life, and the Length of thy days.* (2.) The nearness of Time to the Creation, when the Bodies of Men were of a singular and a most perfect Constitution, Soundness, and state of Health. (3.) The Diet and Feeding was far more wholesome before the Flood, than since. (4.) The Wits and Invention were more accurate and subtil in searching and finding out the Nature and Qualities of all Things whereof they had need to the sustenance of Life, than ours are in these days: And for these Reasons, it may be supposed their Lives were extended to that length.

Neither may we wonder at it, since Heathen Writers testify, That even in their times, some Thousands of years after the Flood, many lived 200, others 300 years: Of some of which, as also of others of later date (even to this present Age) I shall give the Reader an Account:

I. *Hellanicus* (cited by *Pliny*) reports, That in *Ætolia*, many lived till they were 200 years of Age, which *Damastes* confirmeth, while he maketh mention of one *Pictoreus* amongst them, who lived strong and able of Body, till he had fulfilled 300 years.

II. Sir *Walter Raleigh*, in his Discovery of *Guinea*, reports, That the King of *Aromaia*, being 110 years of Age, came in a Morning on foot to him from his House, which was 14 *English* Miles, and returned on foot the same day.

III. *Buchanan* in his *Scotch* History, speaks of one *Lawrence*, who lived in one of the *Orcadean Islands*, Married a Wife after he was above 100 years of Age, and that when he was 120 years old, he doubted not to go a Fishing in a Rough and Tempestuous Sea.

IV. *Sigismundus Polcastrus*, Physician at *Padua*, Read there 50 years; in his old Age he buried four Sons in a short time; at 70 years of Age he Married again, and by this second Wife had three Sons; the eldest of which, called *Antonius*, he saw dignified with a *Degree* in both *Laws*:

*Jerome*, another of his Sons; had his Cap set upon his Head by the Hand of his Aged Father, who trembled, and wept for joy; not long after the old Man died, Aged 94 years.

V. *Fœlix Platerus* saith, That in *Anno* 1572, his Father *Thomas Platerus* buried his Wife, which was *Fœlix's* Mother, and at the 73 year of his Age, Married a second Wife, and within the compass of 10 years had six Children by her, two Sons and four Daughters; the youngest of the Daughters was born in the 81 year of his Age, and he died in the 83 year of his Age. Now that which is memorable between two of his Sons is: I *Fœlix* was born *Anno* 1536. and my Brother *Thomas* 1574, the distance 38 years; and yet this Brother of mine, (to whom (for Age) I might have been Grand-father) is all Grey, and seems elder than my self.

VI. *M. Valerius Corvinus*, lived 100 years, between whose first and sixth Consulship there was 47 years; yet was he sufficient, not only for the most important matters of the Commonwealth, but also for the exactest cultures of his Fields.

VII. *Mitellus* was of the like Age, and was very old when created *Pontiffe*: For 22 years he had the ordering of the Ceremonies: His Tongue never faultered in solemn Prayers; nor his Hand tremble in offering the Sacrifices.

VIII. *Nicholaus Leonicenus*, was in the 96 year of his Age, when *Langius* heard him at *Ferrara*, where he had taught more than 70 years.

IX. *Missanissa* was the King of *Numidia* 60 years together, and excelled all other Men in strength. *Cicero* saith, That for no Cold or Rain he could be induced to cover his Head; He would continue standing in one and the same place, not moving a foot till all about him were weary; and when he was to transact any business sitting in his Throne, he would persist oftentimes the whole day, without turning his Body on this or the other side for a more easeful Posture: He would Lead his Army Day and Night: After the 86 year of his Age he begat a Son, whose name was *Methimnatus*, and died in the 91 year of his Age.

X. *Xenophilus*, the *Pythagorian* Philosopher, and of great Learning was 90 years of Age, and (as *Aristoxenus* saith) died free of all those incommodities that attend upon humane Life.

XI. *Lemnius* tells us of one at *Stockholm*, who at the Age of 100, Married a Wife of 30, and begat Children of her: He looked so fresh, that those that knew him not, deemed him to be not above 50.

XII. *Isocrates*, in the 94th year of his Age put forth his Book *Panathenaicus*, and lived 15 years after it, in which time he was sufficient for any work he undertook, both in Judgment, Strength and Memory.

XIII. The

XIII. The Men of the County of *Cornwall* in *England* are more hardy and ſtrong, alſo very Healthy and Long Liv'd, 80 and 90 years is ordinary: To inſtance in ſome of them :——One *Polzew* lived 130 years, and a Kinſman of his 112.----One *Beancham* 106.---And one *Brown* an *Iriſh man*, but a *Corniſh Beggar*, who lived 120 years; upon whom a Gentleman of this County made this Epitaph:

> *Here* Brown *the quondam Beggar lies,*
> *Who counted (by his tale)*
> *Some Sixſcore Winters and above,*
> *Such Virtue is in* Ale:
> Ale *was his* Meat, *his* Drink, *his* Cloth,
> Ale *did his death reprieve*;
> *And could he ſtill have drank his* Ale,
> *He had been ſtill alive.*

In one Pariſh of this County in the Reign of Q. *Elizabeth*, there died in 14 Weeks ſpace four People, whoſe Ages added together made 340 years.---And farther, One Mr. *Chamond* who lived at *Stratton*, was Uncle, and Great-Uncle to at the leaſt 300 Perſons.

XIV. One Mr. *Macklane*, Parſon of *Lesbury* in the County of *Northumberland*, who died about the year of our Lord 1658, did in the 1656 renew his youth; ſo that (though 40 years before he could not read without Spectacles, being 116 years of Age) he could then read the ſmalleſt Print without them: His Hair, which before he had loſt, came again as a Childs.

XV. In the Pariſh of *Alderbury* in the County of *Shropſhire*, lived one *Thomas Parre*, who was 152 years old, who about two years before he died, was ſent for up to *London* to *White-hall*, by K. *Charles* the Firſt, aud died there *Anno Dom.* 1635.

XVI. One *James Sands* of *Harborn* in the County of *Staffordſhire*, lived 140 years, his Wife 120: He out-lived Five Leaſes of 21 years apiece, made unto him after his Marriage.

## CHAP. V.

### *An Account of the firſt* Authors *of divers famous* Inventions.

I. THE firſt Invention of Printing is attributed by *Peter Ramus* to one *John Fauſt* a *Magnutine*; for he tells us, that he had in his keeping, a Copy of *Tully's* Offices Printed upon Parchment, with this Inſcription at the end of it, *viz. The excellent Work of* Marcus Tullius, *I* John Fauſt *a Citizen of* Mentz, *happily imprinted, not with Writing Ink,* or

*or Brass Pen, but with an excellent Art, by the help of* Peter Gernesham, *my Servant:* Finished it was in the year 1466, the 4th of *February.* Of this Book there are divers Printed Copies seen, by several, for *Pasquier* saith he had one: *Sadmuth* saith, there is one in the Publick Library of *Ausburg*; another in *Emanuel Colledge* in *Cambridge*; another in the Publick Library at *Oxford:* And another of them is (or lately was) in the possession of my worthy Friend, Dr. *Francis Barnard* in *London.*--*Polider Virgil*, from the Report of the *Megamines* themselves, attribute the Invention of this Art to *John Gutenberg* a Knight, dwelling at *Mentz*, *Anno* 1440, and with him agree divers Learned Men; But the forementioned *Faus* (from him) was the first that made proof thereof in Printing of Books, and by what is before said, *Tully's* Offices was the first Book Printed that we have any Record of.---It was first brought into *England*, and practised in *London* by one *William Caxto* Mercer, in the year 1471. As concerning the Printing used in *China* above 1600 years before, it is quite different from what we use now in *Europe:* For whatsoever they Print, is first cut out in Wood, and Inked over with a Ball of Cloath, upon which the Paper being laid, they rowl over with a wooden Rowler covered with a soft Woollen Cloath: which is no other than as Card-Makers Print their Cards; and those that make Patterns for Women and Children to Work by do.

II. Guns, Sir *Walter Raleigh* will have them to be found out by the *Indians*:----*Petrach* and *Vulturius* will have it to be the Invention of *Archimedes:* But the Common (and most received) Opinion is, That it was first found out by a Monk of *Germany*; who, by chance, a spark of Fire falling into a Pot of *Nitre*, which he had prepared for some Chymical Experiment, it caused it to fly upwards: He thereupon made a Composition, which he enclosed in an Instrument of Brass or Iron; and putting Fire to it, found his conclusion to take effect. The first Publick use of Guns (says *Magius*) was about the year 1380, or 1400 (says *Ramus*) at a Battel between the *Genoways* and the *Venetians* at *Cledia Fassa*; where the *Venetians* so galled their Enemies, that they saw themselves wounded and slain, and knew not by what means.

III. The Mariners Compass, an admirable Invention, of which the Time when, and the Author who, is uncertain. Dr. *Gilbers* of *Oxford*, who hath writ a Large and Learned Discourse of the *Load-stone*, seems to be of Opinion, that *Paulus Venetus* brought the Invention from the *Chineses.*——*Osorius* refers it to *Gama* a *Portugal.*----*Goropius Becanus* attributes it to the *Germans*, because the 32 Points of the Compass receive their names from the *Dutch* in all Languages.----But *Blondus*, who is therein followed by *Pancirollus*, will not have *Italy* lose the praise thereof, telling us, that about the year 1300, it was found out at *Melphis*, a City in the Kingdom of *Naples*, but *Blandus* names him not; and the other, *Poncirollus* says, he is not known: Yet *Salmuth*, out of *Ciezus* and *Gomara*, confidently attributes it to *Flavius*, and so doth *Du Bartus*; whose Verses upon this matter (as they are Translated by *Silvester*) are,

> *We're not so much to* Ceres *bound for Bread,*
> *Neither to* Baccus, *for his Clusters Red;*

*As*

*As Siegnior* Flavio *to thy witty Trial,*
*For first inventing of the Sea-mans Dial:*
*The Use of th' Needle turning in the same;*
*(Divine device! O admirable Frame!)*
*Whereby through th' Ocean, in the darkest Night,*
*Our hugest Carracks are conducted right:*
*Whereby we're steer'd with* Trouchman, *Guide and Lamp,*
*To search all Corners of the Watry Camp:*
*Whereby a Ship that Stormy Heavens have whield*
*Near (in one Night) unto the other World,*
*Knows where She is, and in his Chart descries*
*What Degrees thence the Æquinoctial lies,*

IV. Sailing Coaches were the Invention of *Simon Stèvinius* in the *Netherlands*. Of one of these Coaches *Peireskius* made tryal of its swiftness in the year 1606, (after his Victory at *Newport*) he put himself, together with *Francis Mendoza* his Prisoner, into one of them at *Scheveling*, and within two hours they arrived at *Putten*, which is above 40 Miles.

V. Dice, Ball, Cards, Tables, Chess, Draughts, and such like Games, were first invented by the *Lydians*.

VI. The *Phenicians* are said to be the first Builders of Ships; They first invented open Vessels.—The *Ægyptians*, Ships with Decks; and Gallies with two Banks of Oars on a side.—Great Ships of Burthen, were first made by the *Cyprians*.—Cock-Boats and Skiffs by the *Illyrians* and *Libinnians*.—Brigantines by the *Rhodians*.----Frigats or Light Barks by the *Cyrenians*.---- Men of War, by the *Pamphilians*.---- As for Tackle, The *Bœtians* invented the Oar---*Dædalus* of *Crete*, Masts and Sails--- *Anacharsis*, Grapling Hooks---The *Tuscans* Anchors---*Typhis*, the Rudder, Helm, and Art of Steering.

VII. The *Sicilians* (saith *Pliny*) were anciently famous for Invention, as Hour-Glasses, called *Clepsira*: Military Engines, brought to great perfection by *Archimedes*---*Palamedes* first instituted Centinels in an Army, and the Watch-word.---*Penthesilea*, Queen of the *Amazons*, first invented the Battel-Axe.

VIII. The Inhabitants of *Sidon* are said to be the first makers of Glass; the Materials for the Work being first brought over from the Sands of a River running not far from *Ptolomais*, and only made Fusible in this City. The Mystery of making of Glass here in *England* was brought over by one *Benault*, a Foreign Bishop, in the year 662.

IX. To the *Flemings* is attributed the making of Cloath; Arras-Hangings; Dornix and Tapestry, Musical Instruments, Clocks, Watches; Coaches, Chariots, Painting in Oil; Nealing upon Glass, &c. The first that brought Cloathing into *England* was K. *Edward* the 3d, by Transporting some Families of Artificers from *Gaunt* hither.

X. Bra-

X. *Brachygraphy*, or the Art of Writing Short by Characters, is ſaid, by Dion, to be invented by *Mecænas*, the great favorite of *Auguſtus Cæſar*, *ad celeritatem ſcribendi*; for the ſpeedy diſpatch of Writing.

XI. The Baking and Boyling of Sugar, as it is now uſed, is not above 200 years old, and the Refining thereof more new. It was firſt found out by the *Venetians*.

XII. Of Paper; That which was firſt in Uſe, was the Invention of the *Ægyptians*; for on the Banks of the River *Nilus*, grew thoſe ſedgy Weeds called *Popyri*, which have ſince given the Name to Paper. By means of this Invention *Ptolomy Philadelphus* was inabled to make his excellent Library at *Alexandria*. After this (theſe ſedgy leaves being prohibited to be tranſported out of *Ægypt*) *Attalus*, King of *Pergamus*, invented the uſe of Parchment, made of the Skins of Sheep and Calves, from the Materials called *Membrana* and *Pergamena*, from the Place where it was invented. The convenience hereof was ſuch, that in ſhort time the *Ægyptian* Paper was worn out of uſe, in place whereof ſucceeded the Paper we now uſe made of Rags; The Author of which excellent Invention is not left by our Anceſtors to Poſterity: But the Lord *Bacon* reckons it amongſt the ſingularities of Art, although it derives its Pedigree from the Dung-hill.

XIII. Of all the Inventions and Productions of Humane Wit, that of *Writing* is the moſt admirable and Uſeful: For by means thereof, a man may Copy out his very thoughts; utter his mind without opening his Mouth; and ſignifie his pleaſure at any diſtance howſoever remote; and all this by the help of 24. Letters, and in ſome *Alphabets* fewer: By the Various joyning and combining of which, all words utterable or imaginable may be framed: For the ſeveral varieties or changes of theſe 24 Letters, as *Clavius* hath computed (and it is eaſie to do, though laborious) to amount to.

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So that all things that are, or were, or can be imagined to be, may be expreſſed and ſignified by help of this marvelous *Alphabet*. This Miracle of Inventions hath loſt its Maſter, for it is ſet down by *Thomas Read* among the *Inventa Adeſpota*, And thus ſung by him.

*Quiſquis erat, meruit ſenii tranſcendere metas,*
*Et fata neſcire modum, qui myſtica primus*
*Senſa animi docuit, Magicis ſignare Figuris.*

*In* English *thus:*

Who er'e he was, that firſt did ſhew the way,
T' expreſs by ſuch like *Magick* Marks our Minds;
Deſerv'd reprieve unto a longer day,
Than Fate to Mortals moſtly hath aſſign'd.

XIV. Notwithſtanding the Invention of Letters is attributed to the *Phœnicians*, As *Sandys* in Chriſts Paſſion, *Act*. 1.

*Phœnicians*, who did firſt produce
To Mortals, *Letters*, and their Uſe.

The

The *Phœnicians* inhabited between the Great Sea and *Galile* (so called of *Phœnix* their King, the fifth in descent from *Jupiter*:) honoured for the invention of *Letters*: As *Lucan*, Lib. 3.

> *Phœnicians* first exprest (if Fame be true,)
> The fix'd Voice in rude *Figures*. *Memphis* knew
> Not yet how Stream-lov'd *Biblus* to prepare:
> But *Birds* and *Beasts*, carv'd out in stone, declare
> Their *Hierogliphick* Wisdom.——

And these Letters *Cadmus*, the Son of *Agenor*, communicated to the *Grecians*.

XV. The first Invention of the Artificial Sphere or Globe is not evidently know; some think (with *Pliny*) that it was found out by *Atlas*, and carryed into *Greece* by *Hercules*: Others have ascribed it to *Anaximander Milesius*: Some to *Musæus*, as *Diogines Laertius*: And some to other Authors, amongst whom *Architas Tarentius* is not forgotten. But all these were outstript by *Archimedes* the *Syracusan Mathematician*, who flourished *Anno Mundi* 3739, and before the Nativity of Christ 209 years: It was he that composed a Sphere of transparent Glass: Of which you have a description in this Treatise. Sect. Par. 3.

Of such like Spheres *Peter Ramus* sayes he saw two at *Paris*, yet not of Glass but of Iron; the one of which *Ruellius* the *Physician* brought from the *Spoyls* of *Sicily*: The other *Orontius* the *Mathematician* recovered from the *German* Wars.

XVI. *Bells* are imagined to have been invented in the year of our Redemption 400, by *Paulinus* Bishop of *Nola*, a Town in *Campania*, where *Augustus* died: They were called by the Name of *Campana*, because they were invented in *Campania*; and the Lesser Bells *Nola*, from the Place where they were made——The Use of Bells is very great, for by the benefit of them the Hours of the time of the Day or Night are heard a far off, whether we lye in our Beds, be abroad in the Fields, or journying on the way, although the Sun be obscured by Clouds. Moreover, Bells call us to Divine Service: They call for help in time of Fire or other dangers or Mutinies: They call Magistrates of Cities to their Common Halls, Judges to the Bench, Scholars in Universities to Congregations and Disputations: And in a Word, they help us in all publick actions.——And indeed *Paulinus* that Holy and Religious Bishop, did rather reform the abuse of Bells than invent them; and taught them to call Christians to Church to serve God, whereas in former times their chief use was (as they then imagined) to chase away Devils and evil Spirits: they hindred also Magical Inchantments, as *Tibullus* notes, when he thus writes;

> *Cantus & è curru Lunam deducere tentat,*
> *Et faceret si non æra repulsa sonent.*

For they believed, that by the tingling of Brass, that the sound of Magical Verses should be hindred from coming up to the Moon; and when she was moved with these Verses, this Sound relieved her: in

which sense may be taken that of *Statius Papinius*, *Thebaid.* 6.

*——Attonitis quoties avellitur astris,*
*Solis opaca soror, procul auxiliantia gentes*
*Aera crepant, frustaque timent—*

Bells are rung many times in Thunder, to reverberate the infectious Air; the like doth Great Ordnance shot off, as well in Thunder as in soultry and close hot Weather——The *Laconians* when their King dyed, used to beat upon Kettles, instead of Ringing of Bells. The *Africans* (especially those that are *Prester Johns* Subjects) have Bells made of Stone. The *Jews* at Funerals used playing upon Pipes, as it may be gathered out of *Matthew* 9. 18, 23. Which custom it seemed the *Romans* borrowed from the *Jews*, as appeareth by *Ovid*, 1 Trist.

*Tibia funeribus convenit ista meis.*

The Little Bell, which we commonly call the Saints Bell, *John Pierius* useth for an *Hieroglyphick*, Teaching Preachers of Gods Word, that to the sound of their Voice, they should lead their Lives accordingly; else like the Bell, While they call upon others, themselves are deaf and stupid; in allusion whereunto, *Beza* hath this excellent *Epigram.*

*Aera gravi cunctos, veluti Campana sonore,*
*Ipsa licet penitus sunt sibi surda, cient:*
*Sic es recta docens alios, perversa sequnte,*
*Quique alijs sapiens, non sapis ipse tibi.*

And so much concerning the Invention and use of Bells.

XVII. *Lucius Papyrius* was the first that set up a Sun Dial in *Rome*, which being only of use when the Sun shined——And the hourly measure of Time was first found out by *Scipio Massala*; whereas before his time the *Romans* knew no distinction in the time of the Day, than the *Morning Noon* and *Evening*; But afterwards the said Consul. *M. Val. Massala*, beautified a Columb with a Dial neer the *Rostra*, as *Varro* relateth.

XVIII. *Doxius*, the Son of *Cælius*, is said to be the first that built a house in *Athens* who taking his pattern from the Nests of the Swallows, began the way of making of Houses with Clay; whereas, before, men dwelt in Caves and Caverns of the Earth.

XIX. The first that ever began to erect *Obelisqs*, and consecrated them to the *Sun*, they having embossed or ingraven upon them certain Characters and Figures, which were the *Egyptians Hieroglyphicks*, wherein a great part of their best Learning was contained; was *Mitres*, once King of *Egypt*, who held his Court in the Royal City of *Heliopolis*, the City of the *Sun*: And it is said he was admonished in a Vision or Dream so to do: Some of these *Obelisqs* were Stones cut out of the Solid Rock, and very large, some of them have been on every side 7 foot and a half square, at the end and in length 100 foot, as was that of *Ramises*, once King of *Egypt.*

XX. Con-

XX. Concerning the Invention, of the *Telescopick Instrument*, called the *Micrometer*, there are several Competetors; For, *Monus. Petit*, Surveyor of the Fortifications in *France* was the first that published to the World the rough draught thereof in *March* 1667. After him, *Monus. Azout*, another ingenious *Frenchman*, published a Tract concerning the exact measuration of the Planets diameters, wherein he seems to challenge the invention of this Instrument to himself and *Monus Picard*: But last of all, a candid *English-man* of our own, Mr. *Richard Townley*, does vindicate the first contrivance hereof to its true and original Author; One Mr. *Gascoigne*, an *English* Gentleman, who was killed in King *Charles* I. Service, wherein Mr. *Townley* asserts, that Mr. *Gascoigne* made and used this Instrument before the Civil Wars in *England*; and that Mr. *Townley* had then in his custody two or three of those Instruments first devised by Mr. *Gascoigne*, to which Mr. *Townley* himself had added some considerable improvements.

XXI. Concerning *Optick Glasses*, it is evident, by what is said relating to such Glasses either in *Plantus* or *Pliny*, is little to the discovery of the real inventor of them; but rather that the Ancients were wholly ignorant of them; Wherefore, we must necessarily allow their invention due to the Modern Age of the World: And where to fix it we shall now enquire.

One *Monus. Monage*, a learned and ingenious *French-man*, in his *Origini della Lingua Italiana*, Commenting on the Word *Occhiali Galalæi*, discourses there of the time of the invention of *Spectacles*, and there relates, that *Monus. de Cange*, had told him of a *Greek Poem*, the Manuscript whereof is now in the *French* Kings Library, wherein the *Poet* (who lived *Anno* 1150) jesting on the Physicians of those Times, says of them, in *French*; *Qu'ils tatent le Poux*, &c. That they observed the Excrements of their Patients with a Glass: But *Mouns. Monage* is of opinion that this was rather a transparent *Glass* whelmed over the Vessel, more for the relief of their Nose against the *Stench*, than to help their Eyes.

Whether *Spectacles* were of this antiquity, as 1150 or not, is by what is already said, uncertain; but about the 13th Century they were known and used: For in a Letter of *Signior Redi*, Dated *Anno* 1313. He says, *I find my self so pressed by Age, that I can neither read nor* write *without those* Glasses *they call* Spectacles, *lately invented, to the great advantage of poor Old* Men, *when their Sight grows weak.*

*Cursca* in his *Italian Dictionary*, makes this remark on the word *Occhiale*. That Frier *Jordan* in a Sermon of his preached at *Pisa*, An. 1305, tells his Auditory, *That it is not* 20 *years since the Art of making* Spectacles *was found out; and is one of the most necessary Inventions in the World.*

About the same time, *viz.* 1305, *Bernard Gorden*, a famous Physician of *Montpelier*, speaking and commending of an excellent *Eye-Salve*, concludes: That, *If this or the like will not do, They must make use of* Spectacles.

From what hath been said we may conclude, that *Spectacles* were known and used in the 13th Century, and not much before, but who the happy man was, that was the first inventor, Frier *Spina* makes the fairest Challenge to the Invention: But those *Monkish* men (as *Jordan* amongst the rest) had this invention amongst themselves before it was

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publick: and that they all had the first hint thereof from our Countrey-man Fryer *Roger Bacon*; of whom as followeth:

This Learned Fryer *Bacon*, who died *Anno* 1292, and lies buried at *Oxford*, did well understand all sorts of *Optick Glasses*, as plainly appears by his Book of *Perspective*; And that he not only understood the Effects of single *Plain*, *Concave* and *Convex* Glasses; but knew likewise the way of combining them, so as to compose some such *Instrument* as our *Telescope*; And this appears plainly by his own words in the foresaid Book, Part III. Dis. 2. Chap. 3. --*Greater Wonders than all these are performed by Refracted Vision; For, thereby it is easily made appear, That the Greatest Object may be represented as very Little, and contrarily---And so likewise, The most distant Objects as just at hand, and contrarily.---Hereby also may we bring, the Sun, Moon and Stars down here below in Appearance, &c.* And in another place, *viz.* in his Epistle *ad Parisiensem*, of the *Secrets of Art* and *Nature*, Chap. 5. he says,---*Glasses, or Diaphanous Bodies, may be so formed, that the most remote Objects may appear as just at hand, and contrarily; So that we may read the smallest Letters at an incredible distance, and may number things though never so small, and may make the Stars appear as near as we please:* And this I think is sufficient to prove him to be the first Inventor of *Optick Glasses*:-- Yet notwithstanding, the incredible things which this Man performed, (as may be read of him in Dr. *Plott's* *Nat. Hist.* of *Oxfordshire*. Ch. 9. Sect. 2. 3.) yet was he Persecuted by the Ignorant Malicious Fryers of his Order, as practising *Magick* and *Necromancy*, for which they cast him into Prison, and there detained him for a long time, some say to his Death, in the 78th year of his Age; in which time 'tis said, no one was admitted to speak with him; and that all his *Writings*, *Books* and *Instruments* were seized and burnt. And thus leaving Fryer *Bacon* as the Inventor of *Single Convex* and *Concave Glasses*; I shall give an account of some other Inventors of the *Telescope* as now made and used.

*Borellus* has written a small Tract on this Subject, *De vero Telescopii Inventore* wherein (*Chap.* 12.) he seems to give the Invention to *Zacharias Joannides* of *Middleburg* in *Zealand*, *Anno* 1590. Also he names *Johannes Lipperhoy*, or *La Prey*, *Anno* 1609, a Dutchman also; whom *Saturnus* calls *Lippersein*.

*Adrianus Metius*, Mathematical Professor at *Franequer* says, his Brother *Jacobus Metius*, an Alkmaer, was certainly the first inventor of the *Telescope*. And if we believe the *Italians*, we shall have the Honour of inventing this Instrument conferred on the incomperable *Galileo*: But he himself (in his *Nuncius Sidereus*) confesses that the first intimation he received of this Instrument, was, that a *Dutchman* had then lately made one; which set him (*Galileo*) upon the thought how to effect it, which he successfully discovered by the consideration of *Refraction*, and found, that a *Concave* and a *Convex-Glass* rightly adapted, would perform what he only heard in general of the *Dutch* Invention:--- But certainly, the first publick notice of this Contrivance, came from some of the forementioned *Dutch-men*, and therefore is the Instrument deservedly call'd *Tubus Batavus*: Although we must confess, at the same time, that *Galileo*, *Anno* 1610, did first apply this curious Instrument to *Celestial Ob-*

*ser-*

*ſervations*, and had then made ſuch wonderful diſcoveries in the Heavens thereby, that all his Philoſophical Succeſſors have ever ſince attempted to climb higher, by lengthening their Ladder, and advancing this Inſtrument by many Degrees.

XXII. Of the *Microſcope: Franciſcus Fontana*, in his Book Entituled, *Cœleſtium Terreſtiumque Rerum*, challenges to himſelf the invention of the *Double Microſcope*; 'Tis true, that he was the firſt that publiſhed *Microſcopical Obſervations* of ſome few Bodies, in the year 1618. After him *Borellus*, *Anno* 1650; Next, Dr. *Power*, a Learned *Engliſhman* 1664. All theſe went no farther then Verbal Deſcription: But the Learned and Ingenious Mr. *Hook*, in his *Micrographia*, Printed *Anno* 1665. hath preſented to the World curious and lively *Schemes* of ſeveral *Creatures*, and other curious Enquiries. And the Learned Dr. *Grew*, and the excellent *Bononian* Philoſopher, *Marcellus Malphigius*, have laboured moſt ſucceſsfully in the *Anatomy of Plants* by the *Microſcope*: The laſt Author that has profeſſedly treated of *Microſcopick Obſervations*, is *Johan. Fran. Griendelius*, in his *Micrographia nova Norimberg*, 1687. wherein he hath taken a great deal of pains in giving the Genuine repreſentations of his *Objects* as Magnified: And (to conclude this matter) ſays my Author, *Will. Molyneux* of *Dublin* Eſq, "I have been often "delighted with the curious appearance of many Objects ſeen through "the *Microſcope*; But none ever ſurpriſed me more, than the viſible *Cir*-"*culation of the Blood* in *Water-Newts* (*Lacerta aquatica*) to be ſeen as "plainly as Water running in a River, and proportionably much more "rapid.

XXIII. *Of ſuch Cœleſtial Diſcoveries as have in this our Age been made by the help of Teleſcopes.*

As to the firſt Inventors of *Concave* and *Convex Optick Glaſſes*, and how they came firſt to be adapted to *Teleſcopes*, I have in this Book made enquiry into; wherein I at laſt conclude *Galileo* to be deſervedly reputed the firſt that raiſed up this *Gigantick Inſtrument*, that ventures to climb Heaven, and from thence brings down the Stars.

And now to recreate my Reader, I ſhall here recite ſome ſuch diſcoveries as have been made in the *Heavens* in this our Age, by help of theſe *Teleſcopes*: And I ſhall begin my Diſcourſe with the remoteſt Heavens, namely with the *Fixed Stars*, and from them gradually deſcend down to this our *Terreſtrial Ball* by us inhabited. And,

I. *Of the* FIXED STARS.

THat Whitiſh Band or *Zone*, commonly known and called by the name *Galaxia*, or the *Milkey Way*, that ſo irregularly incompaſſes a great ſcope in the *Heavens*, and of which the Ancients could give no tolerable Account, is found by the *Teleſcope* to be no other, than an heap of very minute *Stars* thickly ſet together; which, by their *Great Diſtance*, *Smallneſs* and *Cloſeneſs*, appear to the naked Eye, as one united whitiſh *Cloud*.

Likewiſe thoſe Stars which we call *Nebulus*, as the *Head* of *Orion*, the *Crib* in *Cancer*, *&c.* are found to be a *Congeries* of ſmall Stars cloſely ſet together, but eaſily diſtinguiſhable by the *Teleſcope*.

The *Pleiades*, or *Seven Stars* (though ſcarce more than *ſix* appear) are found by an ordinary Glaſs, to be nigh Forty: And in that one *Conſtellation* of *Orion*, the *Teleſcope* diſcovers more *Stars* than the naked Eye can number in all the *Heavens*.

## II. *Of SATURN.*

THis *Planet* by his ſlow Motion takes State upon him, as carrying about him ſomething more weighty than ordinary; But our ſhort ſight perceives nothing thereof, only a plain Round Globe, as the reſt of the *Chorus* Dancing round the Sun: All his Equipage and Attendants are hid from our view, till ſurveyed more cloſely by the *Teleſcope*; by which you may perceive a mighty *Ring* parallel to the *Equator*, Bright as the *Planets* own *Face*, encompaſſing round his Body; very Thin, and ſeparated in all appearance on all ſides from his Globe: Sometimes appearing *broader*, ſometimes *narrower*; and ſometimes almoſt *vaniſhing*: Then again returning by a regular *Period*, and reſuming by degrees its former ſhape; which again by degrees it loſes according to its own *Periodical Motion*.

But this is not all his *Equipage*; For, beſides this *Throne* of *Light*, this Majeſtick Planet is attended by a *Guard* of *Five Satillets*, that follow his *Motion*, and *Dance* round him continually in a Circle; And theſe were firſt diſcovered by *Galileo* in *October* 1610, but his *Glaſſes* were too ſhort to give the true ſhape of this Planet: But when the *Teleſcope* was farther advanced by *Chriſtopher Hugenius*, to 12 Foot in length, and afterwards, *Anno* 1656, he doubled that length, and then Publiſhed a Treatiſe entituled *Syſtema Saturnum*, in which the *Satillet* which he diſcovered is the fourth from *Saturn*, of which he there gives us the *Epochæ* and *Theorie* of its Motion.

The other four *Satillets* were ſince diſcovered by Monſieur *Caſſini*, in this Order, The *Third* and *Fifth* were firſt ſeen by him *Anno* 1671, 72, and 73, by a 17 Foot Glaſs: But the innermoſt, or *Firſt* and the *Second* were not ſeen by him till the year 1684, at which time having procured Glaſſes of an extraordinary Length, as 80, 100, 150, and 200 Feet; the vaſt *Diſtance* and *ſmallneſs* of theſe *Planets* could no longer conceal them from his ſight: And ſince he hath made *Tables* of the *Motions* of all *Saturns Satillets*, together with their *Diſtances* from *Saturn* correſpondent to their *Periodical Times*.

## III. *Of JUPITER.*

JUPITER next preſents himſelf leſs incumbred than *Saturn*, yet not wanting a Courtly *Train*; For though his *Guards* are but *Four* in Number, yet their *ſize* and *brightneſs* ſhew their *ſtrength*; and their *quick Motion* round about him ſhews their *diligence*.

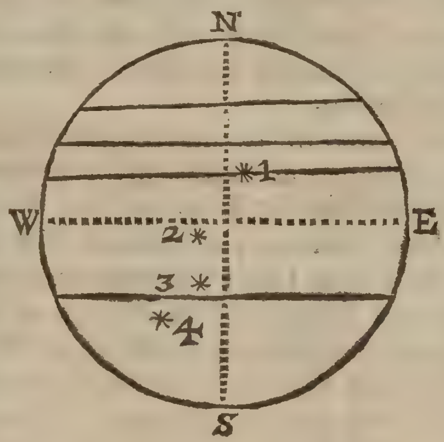
*Galileo* was certainly the Firſt that diſcovered theſe *Satillets*, *Jan.* 7. *Anno* 1610, and from that time to this, no more could ever be diſcovered about him.

Theſe

These *Satillets* are easily seen by a Three-foot *Glass*: Ever since the time of their first discovery, many curious *Astronomers* have attended their *Motion* round *Jupiter* with a diligent Eye, and have found, that sometimes falling into the Shadow of *Jupiter*'s Body, they disappear; and thence emerging, they again become visible: Sometimes they are hid behind the very *Globe* of their *Great Lord*; and sometimes being just in his *Face*, his splendor overcomes theirs, and they become invisible, as a glimmering Lamp between the Eye and Sun.

*John Alfons. Borellus* has Published a Tract of the *Theoricks* of these *Satillets*, *Anno* 1666; but none have laboured more to reduce the Observations of these little Planets to something of *Use* and *Advantage* to the World, than the two Peerless Astronomers of this present Age, *viz. Cassini* and *Flamsteed.*

Besides these Four *Little Moons* about *Jupiter*, the *Telescope* discovers other Remarkables even in his *Body*: As first, His Face is not all of a *Colour*; but there are in it *Brighter* and *Darker Parts*; and these are drawn a-thwart him, like broad *Zones* or *Belts*, almost parallel to the *Ecliptick*, as is expressed in this Figure:




## IV. MARS.

MARS offers himself next, who trusting in his own Strength, is attended by no Guards: But the prying *Telescope* discovers in his *Face*, *Scars*, *Spots* and *Ruggedness*.

By these *Spots* the accute *Cassine* has determined that he turns on his own Axis once in 24 hours and 40 minutes, though others assign his *Revolution* performed in just half that Time.

The *Increase* and *Decrease* in *Light* like our *Moon*, is very visible in this Planet Mars; who in his *Quadratures* with the *Sun*, and his *Perigeon*, may be seen almost *bissected*, but never *Corniculated* or *Falcated*, as the other Inferiors do: But this *Bissection*, and *Increase* and *Decrease* in Light, in regard of the great distance above the Sun) cannot be seen in *Saturn* and *Jupiter*.

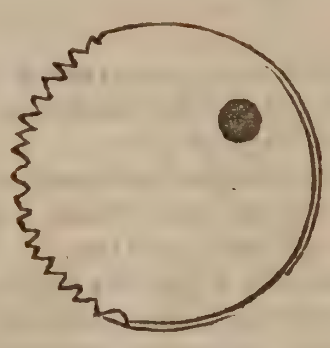
## V. *Of the* S U N.

THe *Sun* in the next place presents it self, in whose bright *Face*, we can hardly expect to find *Dark Spots*, yet such there are, and frequent too, of which, and nothing else, *Schinerus* hath writ a large Book in Folio: And *Hevelius* in his *Selenography* hath many *Observations* of these *Maculæ*; as also, of some *Brighter Spots* in the *Sun*, called *Faculæ*.

The way of *Observing* them (in short) is, Either by admitting the Light of the Sun through a *Telescope* upon a sheet of *White Paper*, in a *Dark Room*; Or by Arming the *Eye* with a small thin *Glass* Smoaked over with a *Torch*, *Lamp* or *Candle*, and with it looking through a *Telescope* at the Suns Body.

The only Discovery that has been made by these *Maculæ* is, That the Sun revolves round his own Axes, in the space of about 25 days and 6 hours. And here it is to be noted, That for these several years past, the appearance of these *Maculæ* has been much more rare, than when *Galileo* (who first discovered them) *Schinerus*, and *Hevelius*, &c. lived: Who attended their Observations, *viz.* between 50 and 60 yerrs ago: About which time one should seldom see the *Suns Face* free from one or more *Black Patches*; but now he seldom wears any, One in *Five* or *Seven* years hardly appearing.

Upon *Tuesday* the second of *July* in the year of Christ 1651, about Eight of the Clock at Night, at *Easton* in *Northamptonshire*, under the Elevation of the *North* Pole, 52 Deg. 15 Min. Dr. *John Twysden* saw in the *Body* of the *Sun*, (through an excellent *Telescope*, whose Glasses are very clean) as he relates in his *Observationes Eclipsium*, a very *dark Round spot*; in *Diameter* about the Twelfth part of the Suns *Diameter*, which to his sight appeared still in the same place for a matter of *Nine* or *Ten Minutes*; tho' thin Clouds oftentime interposed and hindred him from the sight of the *Sun* for a short time. The *Left Margine* of the *Sun* was very *uneven*, and *Tooth'd* in the manner of a *Saw*, as in this *Figure*.



He conceived it was one of those Spots which *Galileus*, *Hevelius*, *Schinerus* and others have observed. *I could not* (says he) *suspect* Mercury *in that place, by reason the latest* Tables *give him near* 5 *deg. of* South Latitude; *though in* Longitude *he be not far distant from the* Sun: *As by the several* Calculations *following may appear :*

Locus

| | | Longit. ☿ S. | D. | M. | So. | Latitude ☿ S. | D. | M. | So. | Longitude ☉ S. | D. | M. | So. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Locus Mercurii ex Tab. | Origani, | 69 | 8 | 58 | 0 | | 4 | 10 | | 69 | 19 | 19 | 16 |
| | Argol. Ephem. | 69 | 9 | 41 | 0 | | 3 | 17 | | 69 | 19 | 42 | 27 |
| | Eichſtad. Eph. | 69 | 19 | 8 | | | 4 | 05 | | 69 | 19 | 45 | 10 |
| | Lansbergii, | 69 | 15 | 48 | 40 | | 3 | 49 | 14 | 69 | 20 | 04 | 03 |
| | Britannicis, | 69 | 18 | 55 | 01 | | 4 | 51 | | | | | |
| | Vincentii Wing, | 69 | 19 | 12 | 41 | | 4 | 53 | | | | | |

*Whatever this* Spot *was, of this I am certain, It was never my fortune ſince to ſee the like* Spot, *nor the* Margine *of the* Sun *ſo uneven, though I have often tryed.*

## VI. *Of VENUS and MERCURY.*

THE Brighteſt *Planet* in the Heavens; *Venus* fears not ſometimes even at Noon-day to diſplay her *Beauty*; She performs her Courſe alone, and free from all other Attendants.

*MERCURY*, Wit and Quickneſs ſecure him, therefore he hath no Train; but generally ſhelters himſelf under the Beams of his Potent Lord the *Sun*.

Notwithſtanding, Both theſe *Inferior Planets* are found by the *Teleſcope* to *Increaſe* and *Decreaſe*, as our *Moon*: For, ſometimes they appear *Corniculated*, ſometimes *Falcated*, ſometimes *Gibbous*, and ſometimes *Full*; on, or near their *Conjunctions* with the *Sun*: By this laſt *Phænomenon* it is manifeſt they move about the *Sun*; ſometimes farther from us, ſometimes nigher to us than *He*; and conſequently the *Ptolomaick Hypotheſis* is evidently diſconſentanious to modern *Obſervations*.

## VII. *Of the MOON.*

WE are now arrived at home, to contemplate our Neighbour the *Moon*: We may properly call her *Our Moon*, as making *Her* the *Centre* of her *Periodical Motion*: For, as the *Satellites* about *Saturn* and *Jupiter* move about *Them*; ſo moves the *Moon* as a *Satellite* about our *Earth*.

*Galileo* with his *Teleſcope* firſt diſcovered great *Ruggedneſs* in the *Moons Face*; after him *Langrenus* attempted to draw her *Picture*: But *Hevelius* has accurately performed that Work; in whoſe *Schemes* we may ſee the *Moons* Countenance diſtinguiſhed in an admirable difference of *Parts*, both for *Shape* and *Colour*. We may there ſee greater parts that reſemble our *Seas*, *Lakes*, *Rivers*, *Iſlands*, *Peninſulaes* and *Continents*: Other leſſer *Spots* that reſemble our *Mountains*, *Hills* and *Valleys*: Thoſe of the *Greater* parts ſomething Obſcure, may we reckon as *Seas*, and *Lakes*; and the *Brighter* we may account *Land*: For ſo does our *Earth* appear, when from a diſtant *Height* we look upon a mixture of *Land* and *Water* enlightned by the *Sun*; Of the ſmaller *Spots*, thoſe that are brighteſt and ſhine, are *Mountains* and *Rocks*: And the *Darker* parts encompaſſing them we may eſteem as *Valleys*.

Now it is manifest by the *Telescope*, That some parts of the *Moon* are much higher than others ; as that some parts of our *Earth* are higher then others. For, If you look upon the *Moon* about the *Quarter* days, we may plainly see the *Edge* towards the *Dark Part*, *broken* and *cragged* ; and many little *Bright Spots* that are clearly separated from the rest of the enlightned *Part* : Which is an evident proof, that these are the high Tops of *Emenencies*, which receive the *Suns* Light before the parts below them are enlightned. Moreover, The *Moons* Spots cast their shadows opposite to the *Sun*, that is, to the *Eastward*, whilst the Moon is *Increasing*, and to the *Westward* on her Decrease.

Now for the better distinguishing these *Spots*, and making them more useful in the *Observation* of *Lunar Eclipses*, there are *Names* imposed upon them by Authors ; *Hevelius assigns* to them the *Names* of *Places* here on *Earth* ; *Grimaldus* and *Ricciolus*, gives to them the *Names* of famous *Mathematicians* and *Astronomers* ; to the great advancement of *Geography* and *Navigation*, in setling the *Longitudes* of Places.

Moreover, By these *Spots* the *Moon* is discovered to have various *librating Motions*, from *East* to *West*, and from *West* to *East* ; also from *North* to *South*, and from *South* to *North*.

ALGE-

# A NEW TREATISE OF ALGEBRA,

According to the late Improvements.

Apply'd to *Numeral Questions* and *Geometry.*

WITH A

CONVERGING SERIES

For all manner of *Adfected Equations.*

By *RICHARD SAULT*, Math. Prof.

In *Adam*'s Court in *Broadstreet*, near the Royal Exchange. *London.*

A PRE-

# PREFACE.

ALGEBRA *depends upon the same Definitions and Axioms that a considerable part of* Euclid's Elements *do, and may therefore very justly be call'd a* New Geometry, *thô it has no small Advantage above that which is commonly called by that Name; since the Substance of whole Sciences at once are sometimes comprehended in one single* Algebraic Theorem; *an Instance of this the Ingenious Mr.* Hally *gives us in the late* Transactions of the Royal Society. *And in many Geometric Constructions, which otherwise would be desperate,* Algebra *furnishes us with such Laws and Rules, as fail not to effect to what we want. So that no one can be a good* Geometrician *that is not a good* Algebraist;*by consequence no tolerable* Mathematician *without it: And since Mathematics are now deservedly grown into that Repute, that they begin to be a necessary part of a Gentleman's Education, (as well as a public Encouragement of them, the Interest of a Kingdom) therefore* Algebra, *amongst other Parts (which in some sense may be term'd the whole) will certainly come in for a considerable Share.*

*As to my own Performance herein, I have omitted nothing that I know of which is useful, but have run through a whole* System *with what brevity and plainness I could, advancing nothing which I have not demonstrated where it's necessary, or shew'd the Reason of the Process. I have applied* Algebra *to Numeral Questions and Geometry, and shew'd the Method of Geometric Constructions; and each of these so far, that afterwards the Learner may proceed himself to what higher Progress his own Industry and Sagacity may prompt him.*

*As for the Business of* Equations,*I have made some little Progress, which I have not seen in any other. In* Quadratics *I find both the Roots at once; and in* Cubics *I have determin'd all the sixteen Cases, and the Qualiities of the Roots, as how great (near) if compar'd with each other, how many Positive, Negative, or Imaginary; and this by considering all the possible Combinations of the Coefficients arising only from three* Geneses, viz. *from three positive Roots, or two Positive and one Negative; or, lastly, from two Negative and one Positive.*

*I have also given an Account of Mr.*Raphson's Converging Series,*with its Demonstration,and an Application of it to several Examples, sufficient to show how all Equations however high or adfected may be easily resolv'd, and have consider'd as previous to this* Series *the Punctation of Adfected Equations which is very useful in Common Practice; thô now there's no absolute necessity of it, for* this *reaches the Case of* Anticipations, *a thing troublesome enough in any* Exegisis Numerosa *that has yet been publish'd.*

*I have yet two other* Infinite Approximations *for all Adfected Equations whatever, built upon very different Principles from that of Mr.* Raphson's, *with new Methods of Extracting Roots, and something else of this Nature, but do not think fit to publish them yet, especially since I'm inform'd that Mr.* Hally *has improv'd* Lagny's *Method for Adfected Equations; which I doubt not but is something worthy the Application of so good a Mathematician as Mr.* Hally *is, and therefore will be very welcome to the Public when he pleases to communicate it.*

*As for the* Errata's *in this Folio, in transposing it to a Quarto, (which I have printed for my own use) I have alter'd most of them; and if there be any other, which in a cursory reading over have escaped me, I will endeavour to satisfy any Person whatever into whose Hands this shall fall, if they please to give themselves the trouble of writing to me about it.*

*An*

## *An Explication of the* Characters.

| | Signifies | |
|---|---|---|
| $a+b$ | | $a$ added to $b$. |
| $a-b$ | | $a$ lessened by $b$, or $b$ subtracted from $a$. |
| $a \times b$ | | $a$ multiply'd into $b$. |
| $\frac{a}{b}$ | | $a$ divided by $b$. |
| $a \backsim b$ | | The Difference betwixt $a$ and $b$. |
| $a . b :: c . \frac{bc}{a}$ | | $a$ is to $b$, as $c$ to $\frac{bc}{a}$. |
| $a . b . c \div\div$ | | $a$, $b$, $c$, are continued Proportionals. |
| $a = b$ | | $a$ is equal to $b$. |
| $a \sqsubset b$ | | $a$ is greater than $b$. |
| $a \sqsupset b$ | | $a$ is less than $b$. |
| $\sqrt{ab}$ | | The Root of $ab$. |
| $\sqrt{\overline{dd+cc}}$ | | The Root of both the Quantities $dd+cc$. |
| $\sqrt{\overline{ddd+\sqrt{\overline{bb+q}}}}$ | | The Universal Root of the Root of $bb+q$ added to $ddd$. |
| $\sqrt{(3)}\overline{a+b}$, or $\overline{a+b}\vert^{\frac{1}{3}}$ | | The Cubic Root of $a+b$, if $\sqrt{(4)}\overline{a+b}$, it had been the Biquadratic; and so of all other Powers. |
| $\overline{a+b}\vert^{\frac{3}{1}}$ | | The Cube of the Binomial $a+b$. |
| $\overline{a+b}\vert^{n}$ | | $n$ may signify the Index of any Power whatever of $a+b$. |
| $\overline{a+b}\vert^{-1}$ | | An Unit divided by $a+b$. |
| $\overline{a+b}\vert^{-3}$ | | An Unit divided 3 times by $a+b$, or by the Cube of $a+b$. |
| $c \times \overline{a+b}\vert^{-\frac{1}{3}}$ | | $c$ divided by the Cubic Root of $a+b$. |
| $\overline{a+b}\vert^{\frac{3}{4}}$ | | The Biquadratic Root of the Cube of $a+b$. |

# ALGEBRA *is the Science of Quantity in General. More Particularly, 'Tis an Art of Reasoning with unknown Quantities, in order to discover their Habitude or Relation to such as are known.*

§. 1. ALGEBRA is term'd *Literal*, or *Specious Arithmetic*, in opposition to the *Numeral*, where the Figures first taken, are lost or swallowed up in others, which by several Operations are deriv'd from them; but in *Letters* the whole Process appears at first sight, and gives one *general Theorem* for all Questions of the same Nature.

§. 2. In any Operation where Letters are alike, they are supposed to be all of the same Nature, as $a$, $\frac{a}{2}$, $3a$, &c. But different Letters suppose Quantities of different Nature, as $b$, $c$, $d$, &c. unless the contrary be exprest, as $b$ & $c$, may be given for two Lines that are known Sides in a Triangle, but of different length.

§. 2. The *Roots* of Quantities are distinguishable by Figures prefix'd, $\sqrt{ab}$, or $\surd(2)ab$, signifies the Square Root of $ab$. $\surd(3)ab$, expresses the Cubick Root of $ab$. $\surd(4)ab$ the Biquadratic Root, &c.

§. 3. *Unity* is suppos'd to be prefix'd to every Quantity, as $1a$, or once $a$, is the same as $a$ it self.

§. 4. If a Quantity have no Sign before it, $+$ is suppos'd to be prefix'd, as $+a$ is the same with $a$.

§. 5. The Sign $\times$ has reference to the whole Quantity that follows or precedes it, if a Line be drawn over every Member thereof, as $a \times \overline{b+c+d}$, or $\overline{b+c+d} \times a$, where $a$ is supposed to be multiplied into each simple Quantity $b$, $c$, $d$.

§. 6. A Quantity drawn or multiply'd into it self, is a Square as $a \times a = aa$; if multiply'd into its self three times, 'tis a *Cube* or third Power, as $a \times a \times a = aaa$; if four times, a *Biquadrate*, or fourth Power, as $a \times a \times a \times a = aaaa$, &c. And so in Figures, 9 is the Square of 3, 64 the Cube of 4, &c. These *literal Powers*, when they rise high, are more commodiously exprefs'd by the Index of the *Power* it self set over them: instead of $aaa$, we write $a^3$, and $a^4$ instead of $aaaa$; suppose the same in the *5th*, *6th*, *7th*, and higher *Powers*.

§. 7. Quantities are *Simple* or *Compound*; *Simple*, when there's but one Member, as $b$, or $bcd$, or $ddgg$, &c. *Compounds*, when connected by the Signs $+$ or $-$, as $a+b$, or $dd-ee+qq$, &c.

## ADDITION *of Algebraic Integers.*

ADDITION *finds the Sum of two or more given Quantities.*

All the possible *Cases* in Addition are *four*.

I. *Where Quantities have the same* Sign *prefix'd, and are of the same Nature.*

*The Reason of the Process.* It's self-evident from the ordinary way of Notation, that 2 and 3 make 5, whatever the things be that are added, provided they be of like Nature; as two Men, two Lines, two like Positions, (or like

like Quantities with the Sign + prefix'd) two like Negations, (or like Quantities with the Sign — prefix'd).

| | | | |
|---|---|---|---|
| To $2a$ | To $+cc-d$ | To $b-dd+ccd$ | To $-10+da$ |
| Add $a$ | Add $+cc-d$ | Add $b-4dd+10ccd$ | Add $+3da-16$ |
| Sum $2a+a$ | Sum $+2cc-2d$ | Sum $2b-5dd+11ccd$ | Sum $-26+14da$ |
| or $3a$ | | | |

II. *Where Quantities are of the same Value and Nature, and have different Signs.*

*The Reason of the Process.* If $A$ has 5000 *l.* and owes 5000 *l.* it's evident that the Sum (or his whole Estate) is o. So also in *Quantities*, if the Line $A$——$B$ be equal to the Line $B$——$C$, and the last be subducted from the first, (or the first lessened by the last) it's manifest that the Whole is taken away, or is equal to o.

| | | |
|---|---|---|
| To $2a$ | To $-dd-ee-f$ | To $13d+25+\frac{1}{3}+qaa+c^3$ |
| Ad. $-2a$ | Add $dd+ee+f$ | Add $-13d-25-\frac{1}{3}-qaa-c^3$ |
| Sum $2a-2a$ | Sum o . o . o | Sum o . o . o . o . o |
| or o | | |

III. *Where Quantities have not the same Value, yet are of like Nature, and have different Signs.* Which is very little different from the former Case.

*The Reason of the Process.* If $A$ has 5000 *l*, and owes 500 *l.* the Whole of his Estate is only lessen'd by so much as the Debt, that is 5000—500, or 4500; but if the Debt had been greater, his Estate had been —4500, or 4500 worse than nothing. Suppose the same in Quantities.

| | | |
|---|---|---|
| To $3a$ | To $3bb+19c-dd-ef$ | To $29bb-c^3+d^5-16q^{13}+17$ |
| Add $-2a$ | Add $-bb-36c+2dd+13ef$ | Add $-13bb+2c^3-10d^5+17q^{13}-13$ |
| Tot. $3a-2a$ | Sum $2bb-17c+dd+12ef$ | Sum $16bb+c^3-9d^5+q^{13}+4$ |
| or $a$ | | |

IV. *Where Quantities are of a different Nature.*

*The Reason of the Process.* Where Quantities are of different Species, (whether the Signs be like or unlike) they are incapable of further Connection, and must therefore be set down with their own Signs prefix'd; two Men and three Horses, make not five Men or five Horses.

| | | |
|---|---|---|
| To $bb-cc$ | To $d^3+qq+dd-b$ | To $13+d$ |
| Add $q+d$ | Add $rr+ss$ | Add $3gg-bb$ |
| Sum $bb-cc+q+d$ | Sum $ddd+qq+dd-b+rr+s$ | Sum $13+d+3gg-bb$ |

## SUBTRACTION *in Algebraic Integers.*

*SUBTRACTION finds the Difference (whether Defect or Excess) between any two propos'd Quantities.*

The three Cases that occur in this Rule, are, Subducting Quantities, whose prefix'd Signs are, (1.) + and +. (2.) + and —. (3.) — and —.

The

*The Reaſon of the Proceſs in each.* } I. To take a Poſitive Quantity out of a Poſitive One, is the ſame thing as to ſubjoin the Defect of the Quantity taken; thus 3 taken out of 5, leaves $5-3$, or 2.

II. To ſubtract a Negative Quantity out of a Poſitive One, is the ſame thing as to ſubtract the Subtraction, or take away the Defect of the Quantity taken; and to take away the Defect of a Quantity, is to put it in a poſitive State: Thus $-3$ taken out of 5, gives $5+3$, or 8.

III. To take a Negative Quantity out of a Negative, is (as before) to take away the Negation of ſuch Quantity. Thus $-3$ taken out of $-5$, gives $-5+3$, or $-2$.

Hence ariſes this general Rule for *Subtraction*, both in whole Numbers and Fractions.

Rule. *Change the Sign or Signs of the Quantity ſubtracting.*

| | | | |
|---|---|---|---|
| From $5a$ | From $3bb$ | From $-3cd$ | From $-dd+ee-gg$ |
| Take $2a$ | Take $-2bb$ | Take $bb$ | Take $-dd+qq$ |
| Rem. $5a-2a$ | Rem. $3bb+2bb$ | Rem. $-3cd-bb$ | Rem. $-dd+dd+ee-qq-gg$ |
| or $3a$ | or $5bb$ | | or $ee-qq-gg$ |

*Note.* That when it's doubtful whether Quantity is greater, the Difference of them is uſually expreſſed by this Character $a \backsim b$, and $\overline{ab-d} \backsim \overline{dd-e}$.

## MULTIPLICATION *in Algebraic Integers.*

MULTIPLICATION *finds the Product or Rectangle of any two propos'd Quantities.*

Since Multiplication is nothing elſe but a taking the Multiplicand, ſo often as there are Unites in the Multiplier. Therefore,

As 1 to the Multiplier ∷ ſo the Multiplicand to the Product.

Here alſo occur three Caſes. (1.) When $+$ multiplies $+$. (2.) When $+$ multiplies $-$, or the contrary. (3.) When $-$ multiplies $-$.

*The Reaſon of the Proceſs in each.* } 1. In multiplying $+4$ into $+5$, I put or repeat the Poſition of 5, ſo often as there are Unites in the Multiplier; therefore the Total will be poſitive, *viz.* $+20$.

2. In multiplying $+4$ into $-5$, I put the Negation of 5 four times; therefore $4 \times -5 = -20$.

And in the Converſe, in multiplying $-4$ into $+5$, I deny the Poſition of 5 four times; therefore $-4 \times 5 = -20$.

3. In multiplying $-4$ into $-5$, I deny the Negation of 5 four times; therefore it's made Poſitive four times, *viz.* $+20$.

4. Multiplication is either of Simple Quantities into Simple Quantities, or Simple Quantities into Compound ones; or, laſtly, Compound Quantities into Compound.

1. *Simple Quantities* are immediately connected.

| | | | |
|---|---|---|---|
| Multip. $a$ | Multip. $3aa$ | Multip. $-3bb$ | Multip. 18 |
| into $b$ | into $-a$ | into $-deg$ | into $dde$ |
| Prod. $ba$ | Prod. $-a^3$ | Prod. $+3degbb$ | Prod. $18dde$ |

2. If one Number multiplies another, the Product ſhall be equal to two Products made of the Multiplication of the firſt Number, into two parts of the ſecond divided at pleaſure: Let 4 multiply 7 for a Product, divide 7 into any two parts, $5+2$; and multiply each part by 4 for two more Products; Then,

$$\left.\begin{array}{r} 7 = 5+2 \\ \underline{4 \quad\; 4} \\ 28 = 20+8 \end{array}\right\}$$ *Hence arises the Method of multiplying a Simple Quantity into every Member of a Compound.*

| | | | | | |
|---|---|---|---|---|---|
| Multip. | $a+b$ | Multip. | $dd-16$ | Multip. | $8-3$ |
| by | $c$ | by | $4$ | by | $6$ |
| Prod. | $ca+cb$ | Prod. | $4dd-64$ | Prod. | $48-18$, or $+30$ |

3. If two Numbers be divided, each into two parts, the Product of the Whole shall be equal to the several Products arising by the Multiplication of all the Parts of the one into all the Parts of the other. Let 7 multiply 8 for a Product, divide 8 into $6+2$, and 7 into $4+3$. Then,

$$\left.\begin{array}{r} 8 = 6+2 \\ \underline{7 = 4+3} \\ 56 = 24+8+18+6 \end{array}\right\}$$ *Hence arises the Method of multiplying every Member of one Compound Quantity into every Member of another.*

| | | | | | |
|---|---|---|---|---|---|
| Mult. | $a+b$ | Mult. | $aa+cc-dd$ | Mult. | $bcd-16$ |
| by | $a+b$ | by | $aa-cc$ | by | $4+cc$ |
| | $aa+ab$ | | $a^4+aacc-aadd$ | | $4bcd-64$ |
| | $ab+bb$ | | $-aacc-c^4+ccdd$ | | $-c^3bd-16cc$ |
| Prod. | $aa+2ab+cb$ | Prod. | $a^4-aadd-c^4+ccdd$ | Prod. | $4bcd-64-c^3bd-16cc$ |

The beginning of the second Book of *Euclid's Elements* demonstrates this by Lines, which I would not have omitted, but that I presum'd the Process here made use of is very evident without it.

*Note.* That since there's no such thing as carrying of Tens, Hundreds, *&c.* to the next place, as in Vulgar Arithmetic, we may begin to multiply either, at the right or left Hand, and set the Results where we please, only by observing the preceding Method, like Quantities usually happen to stand over one another, for the greater conveniency of Addition; as in the first Example, $ab$ and $ab$ make $2ab$; in the second, $aacc$, and $-aacc$ destroy each other.

---

# DIVISION *in Algebraic Integers.*

DIVISION *teaches how to divide a propos'd Quantity into any assign'd Number of equal Parts.*

In common Division 'tis the same thing for Value, whether in dividing 12 by 3, I give 4, or $\frac{12}{3}$ for the Quote. And hence arises the General Rule for Algebraic Division.

*Rule.* Set the Divisor under the Dividend Fraction-wise.

Divide $bc$ by $d$ } the Quote $\frac{bc}{d}$ Divide $aa+bc$ by $de+10$ } the Quote $\frac{aa+bc}{de+10}$

It frequently happens that these Quotes may be reduc'd into lower Terms by the Methods hereafter mention'd; and particularly where the Terms are great, by a Division much like that in Vulgar Arithmetic; only here as in Multiplication, it's necessary to take notice, that if $+$ divides $+$, it gives $+$ in the Quote; if $+$ divides $-$, (or the contrary) there arises $-$; if $-$ divides $-$, the Result is $+$: And because this depends upon the same Reasoning as that in Multiplication, I presume there's no need of Repetition.

Suppose

Suppose I would divide $aaa-eee$, by $a-e$.

$$
\begin{array}{l}
a-e)\,aaa-eee\,(aa+ae+ee \\
\quad\;\; \underline{aaa-aae} \\
\qquad\quad aae-eee \\
\qquad\quad \underline{aae-aee} \\
\qquad\qquad aee-eee \\
\qquad\qquad aee-eee
\end{array}
$$

I first enquire what Quantity multiply'd into $a$, (the first Member of my Divisor) will give $aaa$, (the first Member in my Dividend) and find $aa$; which set in the Quotient, and multiplied into $a-e$, (all the Members of my Divisor) gives $aaa-aae$; which subtracted from the Homologous Term or Terms in the Dividend, leaves $aae-eee$ for a new Dividend: Then I enquire again, what Quantity multiplied into $a$ will give $aae$, and find $ae$; which set in the Quote, multiply'd and subducted as before, leaves $aee-eee$. Again, I enquire what Quantity multiply'd into $a$ will give $aee$, and find $ee$; which also set in the Quote, multiply'd and subducted as before, leaves nothing. More Examples may be these.

$$
\begin{array}{l}
a+b)\,aa+2ab+bb\,(a+b \\
\qquad\;\; \underline{aa+ab} \\
\qquad\qquad ab+bb \\
\qquad\qquad \underline{ab+bb}
\end{array}
\qquad\qquad
\begin{array}{l}
a-d)\,aaa-ddd+b\,(aa+ad+dd+\frac{b}{a-d} \\
\qquad\;\; \underline{aaa-aad} \\
\qquad aad-ddd \\
\qquad \underline{aad-add} \\
\qquad\qquad add-ddd \\
\qquad\qquad \underline{add-ddd} \\
\qquad\qquad\qquad \frac{+b}{a-d}
\end{array}
$$

If (as in the last Example) there be a Remainder when the Division is finish'd, set it Fraction-wise as in Vulgar Arithmetic.

*Note.* Sometimes the Division may not be performed the nearest way, yet the Quotient will be of the same Value, and may be abbreviated.

---

## *Of the Definition, Nature and Reduction of* FRACTIONS.

A *FRACTION is a Part or Parts of an Unit, representing some Divisible Integer.*

§. 1. The Denominator expresses how many Parts *Unity* is divided into, and the Numerator shews how many of those Parts are to be taken; as in $\frac{3}{4}$, *Unity* is divided into four Parts, and three of these four are the Value of the Fraction $\frac{3}{4}$. Hence,

1. When the Numerator is greater than the Denominator, the Fraction is greater than *Unity*, as $\frac{4}{3}=1+\frac{1}{3}$.

2. When the Numerator and Denominator are equal, the Fraction is equal to *Unity*, $\frac{3}{3}=1$.

3. When the Numerator is less than the Denominator, the Fraction is less than *Unity*; in the Fraction $\frac{3}{4}$, 4 is not contain'd once in 3.

In the first case $\frac{4}{3}$ is call'd an *improper Fraction*; and if actually divided into $1+\frac{1}{3}$, it is term'd a *mix'd Number*, as being part Integer and part Fraction; the last Case, *viz.* $\frac{3}{4}$ is call'd a *proper Fraction.*

§. 2. The Ratio of two Numbers, is the Quote of the Antecedent divided by the Consequent.

As the Ratio of 8 to 4 is ( $\frac{8}{4}$ or ) Duple, the Ratio of 4 to 8 is ( $\frac{4}{8}$ or ) Subduple.

Hence, if the Numerator of one Fraction be to its Denominator, as the Numerator of another Fraction to its Denominator, (that is, if their Quotes are equal) then these Fractions are equal, $\frac{8}{4} = 2 = \frac{6}{3}$.

## LEMMA I.

*If a Number multiply two Numbers, the Products arising are in the same proportion to each other as the Numbers multiplied.* Let 2 and 4 be respectively multiply'd by 3. I say (a) 2. 4 :: ( $3\times2.3\times4$ ) 6. 12, for by §. II. $\frac{2}{4} = \frac{6}{12}$.

(a) 17. *Prop.* 7. *Eucl. Coroll. id.*

## LEMMA II.

*If a Number divide two Numbers, the Quotes are in the same proportion to each other as the Numbers divided*, let 6 and 8 be respectively divided by 2. I say, that 6 . 8 :: $\frac{6}{2}$ . $\frac{8}{2}$. that is 6 . 8 :: ( $\frac{1}{2}$6 to $\frac{1}{2}$8 ) 3 . 4 for $\frac{6}{8} = \frac{3}{4}$.

### §. III. *To reduce improper Fractions to Integers.*

Since any Fraction, suppose $\frac{6}{3}$, does not only signify six Thirds of Unity, but also the Third of six Unities: Therefore divide the Numerator by the Denominator, and the Quote shall be an Integer.

$$\text{Divide } 12 \text{ by } 4 \;(= 3 \qquad \text{Div. } ab \text{ by } a \;(= b \qquad \text{Div. } xx + 2xb + bb \text{ by } x + b \;(= x + b.$$

### §. IV. *To reduce Integers to Fractions of the same Value.*

If no Denominator is assign'd, let Unity supply the place, and it's evident the Value is unalter'd.

$$\text{Thus } 13 \text{ is made } \frac{13}{1} \qquad ab = \frac{ab}{1} \qquad xa + cx = \frac{xa + cx}{1}$$

But if the Denominator be assign'd, first imagine the Integer made a Fraction by Unity as before; then multiply the assign'd Denominator into both the Numerator and Denominator, the Fraction arising will keep its Value by *Lemma* I.

Let $a$ have $b$ for its Denominator, then $\frac{a}{1} = \frac{ba}{b}$. Let $bb + cc$, have $e + l$ for a Denominator. Then $\frac{bb+cc}{1} = \frac{ebb+ecc+lbb+lcc}{e+l}$; and so of all others.

From the Converse of this arises the following Case.

### §. V. *To reduce Fractions into lesser Terms (when possible) of the same Value.*

You may, by inspection, discover what Quantity is multiply'd into both the Numerator and Denominator of the given Fraction, divide each Part by that Quantity, and the Quotes will make a new Fraction of the same Value, by *Lemma* II.

Thus $\frac{ba}{b}$ divided by the common Multiplex $b$ produces $\frac{a}{1}$ or $a$; and $\frac{bbe+cce+bbl+ccl}{e+l}$ divided by the common Multiplex $e + l$, is reduced to $\frac{bb+cc}{1}$, or $bb + cc$ of the same Value.

$$\frac{abdd}{bbd}\left\{\begin{matrix}\text{Div. by}\\ bd\end{matrix}\right\} = \frac{ad}{b} \qquad \frac{aa+2ab+bb}{a+b}\left\}\begin{matrix}\text{Div. by}\\ a+b\end{matrix}\right\} = \frac{a+b}{1}, \text{ or } a+b. \quad \frac{dd+e}{dd+e} = 1$$

§. VI.

§. VI. *To reduce mix'd Numbers to Fractions of the ſame Value:*

Firſt (by §. IV.) make the Integral Part a Fraction, whoſe Denominator ſhall be the ſame with that of the Fractional Part given; and to the Numerator of this new Fraction, add the firſt Numerator.

Thus $c + \frac{de}{a} = \frac{ca+de}{a}$. $b + c + \frac{bb+cc}{b-c} = \frac{bb-cc+bb+cc}{b-c}$ or $\frac{2bb}{b-c}$

§. VII. *To reduce two Fractions to two Integers, which ſhall have the ſame Ratio to each other as Fractions given.*

Multiply alternately the Numerator of the firſt by the Denominator of the ſecond, and the Numerator of the ſecond by the Denominator of the firſt, and the two Products ſhall be the Integers ſought.

Thus $\frac{a}{b}$ and $\frac{b}{c}$ are in proportion to each other, as $ac$ and $bb$. For (by *Lemma* I.)

$\frac{a}{b} = \frac{ca}{cb}$ alſo $\frac{b}{c} = \frac{bb}{cb}$ therefore inſtead of uſing the Ratio of $\frac{a}{b}$ to $\frac{b}{c}$ I may uſe that of $\frac{ac}{cb}$ to $\frac{bb}{cb}$ which is equal thereto: But (by *Lemma* II.) $\frac{ac}{cb} . \frac{bb}{cb} :: ac\ bb$. *w.w.*&c.

Thus $\frac{2+ab}{d}$ $\frac{aa-dr}{mm} :: 2mm+abmm.\ daa-ddr.$

Thus alſo $\frac{a+b}{c-e}$ $\frac{c+rr}{p+q} :: pa+bb+qa+qb.\ cc+crr-ec-err.$

And thus, if $\frac{a+b}{c} = \frac{dd}{rr}$, then alſo $arr+rrb=cdd$, which will be of frequent uſe hereafter in the Reduction of Æquations.

§. VIII. *To reduce Fractions to a Common Denominator, retaining the firſt Value.*

Multiply alternately the Denominator of the laſt Fraction, into both the Numerator and Denominator of the firſt, and the Denominator of the firſt into the Numerator and Denominator of the laſt, the two new Fractions will be of the ſame Value by *Lemma* I.

Thus $\frac{a}{b} + \frac{c}{d}$ are reduced to $\frac{da}{db} + \frac{bc}{bd}$ that is $\frac{da+bc}{db}$

Thus alſo $\frac{aa+cc}{rr} + \frac{dp-gg}{b} = \frac{baa+bcc+dprr-ggrr}{rrb}$.

If there be more than two Fractions to be reduc'd to a common Denominator, firſt reduce two of them, as above, then there will be one leſs than before; and ſo on till they are all reduc'd to one: or which is the ſame thing, and perhaps ſhorter, multiply the Numerator of each Fraction into all the Denominations of the others, for new Numerators; then multiply all the Denominators together for a new Denominator.

$\frac{a}{b} + \frac{c}{d} + \frac{e}{f} = \frac{adf+cbf+cbd}{baf}$. And ſo alſo in Compound Quantities.

§. IX. *To reduce Fractions to a Common Denominator of the ſame Value, and in the leaſt Terms, when it may be done.*

(1.) If poſſible, reduce the two Fractions propos'd into the leaſt Term, by the greateſt Common Diviſor, (*per Lemma* II.) Then multiply alternately as before, (§. VIII.) (2.) If this is not to be done; (1.) Divide the two Denominators by the greateſt Common Diviſor. (2.) Multiply the Alternate Numerators by theſe Quotes for new Numerators. (3.) Multiply either of the Denominators by its Alternate Quote for a Common Denominator.

The Abbreviation here (which is of very great uſe) depends on this, That every Member of the New Fraction, is the Quote of every Member of the old One, (when reduc'd as above) divided by the Common Diviſor of the old Denominator, *viz.* $a$; and therefore this Fraction is equal to what it would have been by §. VIII. *viz.* $\frac{nrsa+nad+satqq-aatm}{aatn}$, as is evident by *Lemma* II.

Let $\frac{rs+d}{ast}$ and $\frac{qq-m}{ns}$ be propos'd.
$a$ the Common Diviſor.
$at$ and $n$ the Quotes.
$\frac{nrs+nd+atqq-atm}{aatn}$ the New Fraction.

Theſe 9 Sections well underſtood, there is no difficulty in *Addition, Subtraction, &c.*

---

## Addition *and* Subtraction *of Algebraic Fractions.*

FRACTIONS *(if need be) being firſt reduc'd to a Common Denominator,* (by Lemma I.) *add or ſubtract the Numerators as in Integers, and ſet the Sum or Remainder over the common Denominator.* For from the common way of Notation $\frac{1}{4}+\frac{2}{4}$ of the ſame thing, make $\frac{3}{4}$; alſo $\frac{3}{4}-\frac{1}{4}$ of the ſame thing, is $\frac{2}{4}$ or $\frac{1}{2}$.

*Examp.* 1. To $\frac{2}{4}$, Add $\frac{3}{4}$, Sum $\frac{5}{4}$.
To $\frac{2}{3}$, Add $\frac{3}{4}$, Sum $\frac{17}{12}$ when reduc'd.

$$\left.\begin{array}{l}\text{To } \frac{ab+cd}{de} \\ \text{Add } \frac{3gg+xx}{de}\end{array}\right\}\text{Sum is } \frac{ab+cd+3gg+xx}{de}$$

*Examp.* 2. From $\frac{3}{6}$, Take $\frac{2}{6}$, Rem. $\frac{1}{6}$.

$$\left.\begin{array}{l}\text{From } \frac{2ab-cc}{gg} \\ \text{Take } \frac{ab+cc}{gg}\end{array}\right\}\text{Rem. is } \frac{{}^{*}2ab-cc-ab-cc}{gg} \text{ or } \frac{ab-2cc}{gg}$$

* *Remember as in whole Numbers, to change the Sign or Signs of the Quantity ſubtracting.*

---

## Multiplication *of Algebraic Fractions.*

§. 1. IN Multiplication of *proper* Fractions, the Product is leſs than either of the Factors.

*Demonſtr.* I would multiply $\frac{2}{3}$ into $\frac{3}{4}$. From the Definition of Multiplication,

$1 . \frac{2}{3} :: \frac{3}{4}$ to a fourth Proportional. But $1 \sqsubset \frac{2}{3}$; therefore $\frac{3}{4} \sqsubset$ Product; or alternately.

$1 . \frac{3}{4} :: \frac{2}{3}$ to a fourth Proportional. But $1 \sqsubset \frac{3}{4}$; therefore $\frac{2}{3} \sqsubset$ Product. *w. was to be dem.*

§. 2. Fractions (if poſſible) being firſt reduc'd into lower Terms, multiply the Numerators together for a Common Numerator, and the Denominators for a Common Denominator.

$\frac{2}{3}\times\frac{3}{4}=\frac{6}{12}$ or $\frac{1}{2}$ in the loweſt Terms. $\frac{a}{b}\times\frac{d}{c}=\frac{ad}{bc}$.

$$\left.\begin{array}{l}\text{Multip. } \frac{bb+2cd}{r-t} \\ \text{into } \frac{3dr-2cd}{2r}\end{array}\right\}\text{The Product ariſing is } \frac{3drbb+bcddr-2cdbb-4ccdd}{2rr-2rt}.$$

To demonstrate the Truth of the preceeding Rule, *viz.* $\frac{2}{3} \times \frac{3}{4} = \frac{6}{12}$. From the *defin.* of Multiplication, $1 . \frac{2}{3} :: \frac{3}{4}$ to a fourth Proportional; I am therefore to prove that $1 . \frac{2}{3} :: \frac{3}{4} . \frac{6}{12}$: Or in Letters, $1 \; \frac{b}{a} :: \frac{a}{c} \left(\frac{ab}{ac}\right) \frac{b}{c}$ instead of 1 put $\frac{a}{a}$ equal to it, (to bring it in the same denomination with the next Term); then $\frac{a}{a} . \frac{b}{a} :: \frac{a}{c} . \frac{b}{c}$, that is by *Lemma* II. $a . b :: a . b$, which is evidently true; therefore by equality of Proportion, $1 . \frac{b}{a} :: \frac{a}{c} \left(\frac{ab}{ac}\right) \frac{b}{d}$; or $1 . \frac{2}{3} :: \frac{3}{4}, \frac{6}{12}$, *which was to be demonstrated,*

---

## Division *of Algebraic Fractions.*

§. I. IN the division of proper Fractions, the Quote is $\sqsubset$ than either the Divisor or Dividend.

*Demonst.* I would divide $\frac{2}{3}$ by $\frac{3}{4}$, or the contrary: from the Definition of Division; As Divisor to Unity :: so Dividend to the Quote. Then $\frac{2}{3} . 1 :: \frac{3}{4}$ to a fourth Proportional; which must be $\sqsubset$ than $\frac{3}{4}$, because $1 \sqsubset \frac{2}{3}$. and alternately, $\frac{3}{4} . 1 :: \frac{2}{3}$ to a fourth Proportional, which must be $\sqsubset$ than $\frac{2}{3}$, because $1 \sqsubset \frac{3}{4}$; *which was to be demonstrated.*

§. II. Fractions (if need be) being first reduc'd to a Common Denominator in the lowest Terms, cast away such Common Denominator, and divide the Numerator of the Dividend by the Numerator of the Divisor.

Divide $\frac{5}{4}$ by $\frac{3}{4}$ } the Quote is $\frac{5}{3}$. For by *Lemma* II. $\frac{5}{4} . \frac{3}{4} :: 5 . 3$.

Divide $\frac{aa+2ab}{3d}$ by $\frac{bb-2ab}{3d}$ } Quote $\frac{aa+2ab}{bb-2ab}$. And so of all others, whether Fractions proper, improper, or mix'd Numbers when reduc'd to a Common Denominator.

---

## *Of the* Genesis *and* Analysis *of* Powers.

§. I. BY the word *Powers*, is meant *Squares*, *Cubes*, *Biquadrates*, &c. as before. By the *Genesis of Powers*, is understood a Procreation of them, arising by the continual Multiplication of some *Root* into it self; as if $a$ be the Root, then $a \times a$ or $a^2$ is the second *Power*; $a \times a \times a$, or $a^3$ is the third *Power*, and so on: 'Tis the same if the Root be a *Binomial*, $a+b$; a *Residual*, as $a-b$; a *Trinomial*, as $a+b+c$; a *Quadrinomial*, as $a+b+c+d$, *&c.*

But the *Power* of a *Binomial*, being the most proper and easy to be resolv'd again into its Root; (which Resolution is what is meant by *Analysis*) I shall only prosecute the Generation of *Powers* from it. *Ex. Gr.*

$a+b$, the Root.

* $\overline{a+b}|^2$, or $aa+2ab+bb$, the Square.

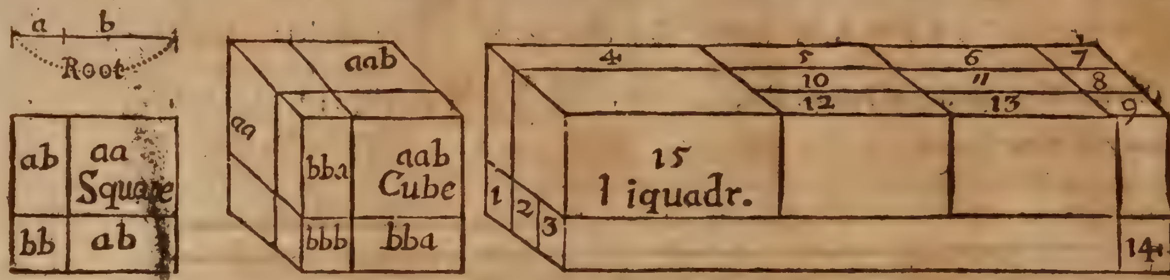
$\overline{a+b}|^3$, or $aaa+3aab+3abb+bbb$, the Cube.

* *See the Characters at the beginning.*

$\overline{a+b}|^{\frac{4}{1}}$, or $a^4+4a^3b+6aabb+4ab^3+b^4$, the Biquadrate.

$\overline{a+b}|^{\frac{5}{1}}$, or $a^5+5a^4b+10a^3bb+10aab^3+5ab^4+b^5$, the Cubiquadrate, &c.

*Which* Powers *may be thus represented in* Plano.




The Parts of the Square are all apparent.
The Parts of the Cube are all visible except *aaa*, which lies under the highest *aab*.

In the Biquadrate the Parts lie thus.

| | | | | |
|---|---|---|---|---|
| 1. $a^3b$ | 4. $abbb$ | 7. $a^2b^2$ | 10. $a^2b^2$ | 13. $ab^3$ |
| 2. $a^3b$ | 5. $a^4$ | 8. $a^2b^2$ | 11. $a^2b^2$ | 14. $ab^3$ |
| 3. $a^3b$ | 6. $a^3b$ | 9. $a^2b^2$ | 12. $a^2b^2$ | 15. $ab^3$ |

16. *bbbb*, lies under 13, $ab^3$. all the rest are visible.

§. II. All Higher Powers may be represented in *Plano*, and will be Parallelipipedons, which I have not found any one yet take notice of, only the length of them will depend upon the Value of their *Binomial Root*, and where we come to have a higher Power than a Cube. Suppose *bbba*, it's but multiplying *b* into its self, and let the Product extend in length; and then the two other parts multiply'd into that length, shall make up a Parallelipipedon.

§. III. From the Process in the preceding *Genesis*, which is our Exemplar in all Cases that can happen, we have a Method of generating Powers from any given *Root*.

Suppose I would have the Square of $dd+rr$, or $\overline{dd+rr}|^{\frac{2}{1}}$; I must make it to answer the respective Parts of the Square of $a+b$. Thus,

$$\left.\begin{array}{r|l} aa & d^4 \\ 2ab & 2d^2r^2 \\ bb & r^4 \end{array}\right\} \text{the Square sought.}$$

§. IV. If the Root be a *Trinomial*, or have yet more Members, the Case is still the same, only $aa+2ab+bb$, must be repeated so many times save one as there are Members in the given Root. For Instance, if the Root be a *Trinomial*, there will be two Operations.

Suppose $\overline{dd-2de+qq}|^{\frac{2}{1}}$ was demanded; (1.) Square the two first Members as in the Margin. (2.) Let the two first Members be *a*, and the next be *b*, then will *aa* be equal to the Square of the two first Members, and the second Operation will be thus.

$$1st.\left\{\begin{array}{r|l} aa & +dddd \\ 2ab & -4d^3e \\ bb & +4ddee \end{array}\right\} \text{The Square of the first two Members.}$$

$$2d.\left\{\begin{array}{r|l} aa & d^4-4d^3e+4ddee \\ 2ab & 2ddqq-4dqqe \\ bb & qqqq \end{array}\right.$$

This might have been perform'd, by squaring the whole Quantity at once; but it's done *gradatim*, for a plainer insight in the Extraction of Roots, which is only the reverse hereof, and must (ordinarily) be performed *quadratim*. But to apply this to Numbers.

The whole Square sought. $d^4-4d^3e+4ddee+2d^2q^2-4dq^2e+q^4$.

Suppose

Suppose $\overline{2612}|\div$ was demanded, we are here to use the same Process as in the last Example, only 'tis necessary to have respect to the number of Places, as the Square of the first Figure 2, or 2000, will have six Ciphers after it; the Rectangle of 2 into 6, or $2000 \times 600$, will have Ciphers. The Square of 6, or 600, is 36 with four Ciphers; and so of all others.

| | | |
|---|---|---|
| *aa* | 4 . . . . . . | $a=2$ |
| 2*ab* | 24 . . . . . | $b=6$ |
| *bb* | 36 . . . . | |
| *aa* | 676 . . . . | $a=26$ |
| 2*ab* | 52 . . . | $b=1$ |
| *bb* | 1 . . | |
| *aa* | 68121 . . | $a=261$ |
| 2*ab* | 1044 . | $b=2$ |
| *bb* | 4 | |

6822544 the whole Square of the given *Root*, *viz.* 6212.

§. VI. The Reverse of this Procedure furnishes us with a Method for the *Analysis* or Extraction of Square Roots.

Suppose $\overline{aa+2ab+bb}|\div$ was demanded, (1.) I extract the Root of *aa*, which squar'd set in the Quote, and subducted from *aa*, leaves nothing.

$$\begin{array}{l} aa+2ab+bb\,(a+b \\ \underline{aa} \\ \quad 2ab+bb \\ \quad 2ab+bb \end{array}$$

(2.) To find the other Member of the Binomial, *viz.* *b*, I have the double Rectangle of 2*ab*; *a* is already found, by consequence 2*a* one of the Factors; but if a Rectangle be given, and one of the Factors, the other Factor is given by Division, *viz.* $\frac{2ba}{2a}(\,b.$ having found the other Member, square it, multiply it into the Divisor, and subduct the Products from $2ab+bb$, (which must be first brought down as in common Division) and there remains nothing.

1. Hence the in extracting Square Roots, the Divisor is always twice the Quotient.

2. The *Resolvend* does always contain, or at least is equal to ( $2ab+bb$, or ) the Square of the Figure last set in the Quote, more two Rectangles of the last Figure into all the Quote.

3. The *Ablatitium* or Number subtracting, is always $2ab+bb$ exactly.

4. From the Order and Nature of places Unity in the Divisor, will stand under Tens in the Resolvend.

But in order to discover the Square, Cubic, or Biquadratic Root of the first Punctation (as also further if need be) in Numeral Extractions, the following Table may properly intervene here, whose Use is briefly thus.

What's the nearest Square Root of 6; this lies betwixt 4 and 9 in the Column of Squares, and therefore the next Square Root under the Truth is 2 opposite to 4. Thus the next Square Root of 79, is that of 64, *viz.* 8. The next Cube Root of 187, is that of 125, *viz.* 5. The next Biquadrate Root of 4563, is that of 4096, *viz.* 8, &c.

*A Table of Numeral Powers.*

| √ | Sq. | √ | Sq. | √ | Sq. | √ | Sq. | √ | Sq. |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 21 | 441 | 41 | 1681 | 61 | 3721 | 81 | 6561 |
| 2 | 4 | 22 | 484 | 42 | 1764 | 62 | 3844 | 82 | 6724 |
| 3 | 9 | 23 | 529 | 43 | 1849 | 63 | 3969 | 83 | 6889 |
| 4 | 16 | 24 | 576 | 44 | 1936 | 64 | 4096 | 84 | 7056 |
| 5 | 25 | 25 | 625 | 45 | 2025 | 65 | 4225 | 85 | 7225 |
| 6 | 36 | 26 | 676 | 46 | 2116 | 66 | 4356 | 86 | 7396 |
| 7 | 49 | 27 | 729 | 47 | 2209 | 67 | 4489 | 87 | 7569 |
| 8 | 64 | 28 | 784 | 48 | 2304 | 68 | 4624 | 88 | 7744 |
| 9 | 81 | 29 | 841 | 49 | 2401 | 69 | 4761 | 89 | 7921 |
| 10 | 100 | 30 | 900 | 50 | 2500 | 70 | 4900 | 90 | 8100 |
| 11 | 121 | 31 | 961 | 51 | 2601 | 71 | 5041 | 91 | 8281 |
| 12 | 144 | 32 | 1024 | 52 | 2704 | 72 | 5184 | 92 | 8464 |
| 13 | 169 | 33 | 1089 | 53 | 2809 | 73 | 5329 | 93 | 8649 |
| 14 | 196 | 34 | 1156 | 54 | 2916 | 74 | 5476 | 94 | 8836 |
| 15 | 225 | 35 | 1225 | 55 | 3025 | 75 | 5625 | 95 | 9025 |
| 16 | 256 | 36 | 1296 | 56 | 3136 | 76 | 5776 | 96 | 9216 |
| 17 | 289 | 37 | 1369 | 57 | 3249 | 77 | 5929 | 97 | 9409 |
| 18 | 324 | 38 | 1444 | 58 | 3364 | 78 | 6084 | 98 | 9604 |
| 19 | 361 | 39 | 1521 | 59 | 3481 | 79 | 6241 | 99 | 9801 |
| 20 | 400 | 40 | 1600 | 60 | 3600 | 80 | 6400 | 100 | 10000 |
| √3. | Cub. | √3. | Cub. | √3. | Cub. | √4. | Biqua. | √4. | Biquad. |
| 1 | 1 | 11 | 1331 | 21 | 9261 | 1 | 1 | 11 | 14641 |
| 2 | 8 | 12 | 1728 | 22 | 10648 | 2 | 16 | 12 | 20736 |
| 3 | 27 | 13 | 2197 | 23 | 12167 | 3 | 81 | 13 | 28561 |
| 4 | 64 | 14 | 2744 | 24 | 13824 | 4 | 256 | 14 | 38416 |
| 5 | 125 | 15 | 3357 | 25 | 15625 | 5 | 625 | 15 | 50625 |
| 6 | 216 | 16 | 4096 | 26 | 17576 | 6 | 1296 | 16 | 65536 |
| 7 | 343 | 17 | 4913 | 27 | 19683 | 7 | 2401 | 17 | 83521 |
| 8 | 512 | 18 | 5832 | 28 | 21952 | 8 | 4096 | 18 | 104976 |
| 9 | 729 | 19 | 6859 | 29 | 24389 | 9 | 6561 | 19 | 130321 |
| 10 | 1000 | 20 | 8000 | 30 | 27000 | 10 | 10000 | 20 | 160000 |

**§. VII. To apply the preceding Extraction to Numbers.**

Suppose $\dot{6}82\dot{2}5\dot{4}4|^{\frac{1}{2}}$ was demanded: After pointing of every other Figure, beginning at the right Hand, the nearest Root (under truth) of the first Punctation, is 2; which squared, set in the Quote, and subducted from 6, leaves 2: Bring down the next Punctation 82, then is 282 (the Resolvend) $= 2ab + bb$; therefore double the Quote, *viz.* $= 2a$, and thereby divide only the two first Figures of 282; to leave room for the Square of the Quote, which is part of the Ablatitium; and there arises 6; which squar'd, multiply'd by the Divisor, and the Sum subducted from 282, leaves 6.

3. Let $a = 26$, bring down the next Punctat. 25, then is $625 = 2ab + bb$. To find

```
           6822544(2612 Root.
           4......  Ablatitium.
  2a..4)282....     Resolvend.
         36 == bb
        24  == 2ab
        276.....    Ablatit.
  2a..52)625...     Resolv.
           1 = bb
         52  = 2ab
         521...     Ablatit.
  2a.522)10444.     Resolv.
             4=bb
         1044 =2ab
         10444      Ablat
             0.
```

find $b$, square the Quote, *&c.* continuing the same Operation as before through all the Punctations, and the Process will appear as in the Margin.

But since the Tens resulting in squaring 6, (the second Figure in the Quote) may be carried to the Tens in $2ab$, (the other part of the Ablatitium) therefore the Operation may be abbreviated here, though it can't (ordinarily) in higher Powers. Thus.

$$\begin{array}{rl} & \dot{6}8\dot{2}2\dot{5}4\dot{4}\,(\,2612 \text{ Root.} \\ & \underline{4} \\ 4) & 282 \\ & \underline{276 = 2ab + bb} \\ 52) & 625 \\ & \underline{521} \\ 522) & 10444 \\ & 10444 \end{array}$$

The proof of a Square Extraction. If there be any Remainder, subtract it from the Sum propos'd to be extracted, and the Remainder shall be equal to the Square of the Quote or Root found, if true, *Ex. gr.* the Root of 6094 is 78, and there remains 10 after the Extraction; extract this 10 from 6094, and there rests 6084 equal to the Square of Quote or Root 78. If there's no Remainder, the Quote squar'd will give the Sum again, as the square Root of 5625 is 75 without a Remainder, for the Square of 75=5615.

§. VIII. If the Quantity propos'd be not a perfect Square, it may nevertheless be continued after the same manner, by a *Converging Series*, nearer the Truth than any assign'd Quantity.

Suppose $\overline{aa+b}|^{\frac{1}{2}}$ was demanded:

$$\begin{array}{rl} & aa+b\,\left(a+\frac{b}{2a}-\frac{bb}{8a^3+4ab}\right., \&c. \\ & \underline{aa} \\ 2a) & +b \\ & b+\frac{bb}{4aa} \\ \frac{2aa+b}{a}) & -\frac{bb}{4aa} \end{array}$$

If the Quote be continued infinitely, the same Method of procedure will continue infinitely: *viz. Always square the Quantity last set in the Quote, and divide the Product by twice the whole Quote:* After the two first Quantities, this will be always a Negative Series. From hence we have a new Method of extracting Square Roots, to an hundred Figures or more in an hour or two's Time, which by the common Methods can't be done in so many Years, perhaps not in an Age.

I have seen a small Abstract of *Father Lagny*'s *Novelles Methodes*, &c. which is built (I presume) upon this Principle, and has the same Pretensions, though the Abstract was too short and imperfect to find the Reason of his Process. Also our own Ingenious Mr. *Raphson* was pleased to shew me the same *Series* himself; and I doubt not but if he would allow himself Time to prosecute it, he might make the same Application, and perhaps better than I have done. Mine was this;

1. I consider'd, that in extracting the Square Root of any Figure, suppose 2, to any Number of Decimal Places, suppose 27, at the same time I extracted the Root of *two hundred Millions of Millions of Millions of Millions.*

2. That in extracting the Root of four Figures, I should not miss Unity, if I extracted only the Root of the two first with two Ciphers; or if of eight Figures, the Root of 4 with four Ciphers; if of sixteen Figures, the Root of 8 with eight Ciphers: and so on.

3. That in the Operation, great care ought to be taken, that the Surplusage after Extraction be added in its proper Place; and that also in subtracting the Square of the true Root from its correspondent Place, the same Caution be observed; which perhaps is easiest done, supposing all to be Decimals after the first Punctation, till the Operation be finish'd.

*From the preceding Considerations.*

Suppose $\overline{200000000000000000000000000}|^{\frac{1}{2}}$ were demanded.

$A\ B\ C\ \ D\ \ E$

200000000000000000000000000

2) 10 (5

..... Rem.

3) −25 (83

10

−1000 Resolv. = Rem. + $C$.

−6889 Ablat. = $\overline{83}|^{\frac{2}{1}}$

$\overline{-7889\times 2834}|^{-1}$ (= −2783

−1978000 Resolv. = Rem. + $D$.

−7745089 Ablat. = $\overline{2783}|^{\frac{2}{1}}$

$-9723089\times\overline{2828434}|^{-1}$ (= − 34376220.

15 the Root of $A+B$
−83 Root of $C$

1417 the Sum.
−2783 Root of $D$

1414217 the Sum.
−34376220 Root of $E$

14142135623780 Root total.

If there had been 32 Figures more of any sort, Ciphers or not Ciphers, in the Number propos'd, one bare Division more would have given their sixteen radical Figures; which is an immense abbreviation, and perhaps incredible to such as do not apprehend the Reason of it.

Here also might be shew'd from the same Principle, a prodigious short way of squaring any large Number near, but this would be too great a Digression in this place, and foreign to my purpose at present.

This I believe is as short a Method as is yet publish'd, and I am sure not yet commonly known; though I have two others, one built upon Mr. *Raphson*'s *Numeral Series*, considerably shorter in practice than this: The other much shorter than either, which gives the Radical Integers of the whole Sum propos'd only by Inspection, or at least by one Division, and converges as fast in Decimals as either of the other; but this I do not yet think fit to publish, because I hope to make a farther progress in it as to its application to all sorts of adfected Æquations.

§. X. From the *Binomial* $a+b$, is generated (as before) $\overline{a+b}|^{\frac{3}{1}}$, or $a^3+3aab+3abb+b^3$, which is a standing Original for the Genesis of a Cube from any given Root.

Let $\overline{d-13}|^{\frac{3}{1}}$ be propos'd, and the Members resulting will answer the respective Parts in the Original, as in the Margin. Suppose the same in a *Trinomial*, *Quadrinomial*, &c.

| | |
|---|---|
| $aaa$ | $ddd$ |
| $3aab$ | $-39dd$ |
| $3abb$ | $+507d$ |
| $bbb$ | $-2197$ |

Let $\overline{57209}|^{\frac{3}{1}}$ be demanded.

As in the Square, so here we must observe the Order of Places, the Cube of 5 having twelve Places or Ciphers after it, &c. Also $a$ is first equal to 5, and $b=7$; then $a=57$, and $b=2$. Again, $a=572$, and $b=0$. Lastly, $a=5720$, and $b=9$.

| | |
|---|---|
| $a^3$ | 125............ |
| $3a^2b$ | 525........... |
| $3ab^2$ | 735.......... |
| $b^3$ | 343......... |
| $a^3$ | 185193......... |
| $3a^2b$ | 19494........ |
| $3ab^2$ | 684....... |
| $b^3$ | 8...... |
| $a^3$ | 187149248...... |
| $3a^2b$ | 8833968.... |
| $3ab^2$ | 138996.. |
| $b^3$ | 729 |
| | 187237601580329 |

§.XI. As for the Analysis or Resolution of the Cube into its Root, we have no more to do than to find the Members that compose it, (suppose it to be a *Binomial*) one whereof is discover'd by inspection, and the other as in the subsequent Operation.

Let

Let $\overline{a+b}|^{\frac{1}{3}}$ be demanded.

1. Set the Root of the first Member *aaa* in the Quote; Cube it, and subtract from *aaa*, there rests nothing.

| | | |
|---|---|---|
| | $aaa+3aab+3abb+bbb$ ( $a+b$ | |
| | $aaa$ | |
| $3aa$ ) | $3aab+3abb+bbb$ | Resolvend. |
| | $3aab+3abb+bbb$ | Ablatitium. |

2. To find the other Member *b*, we have $3aab$; *a* is found already, and by consequence $3aa$; but having the whole Product $3aab$, and one of the Factors, *viz.* $3aa$, the other also is found by Division $\frac{3aab}{3aa}=b$.

Set *b* in the Quote, Cube it, multiply the tripple Square thereof into all the Quote, (which here is only *a*); multiply also the tripple thereof into the Quote (*a*) Squar'd; which several Products subtracted from the respective Members in the Resolvend, leaves nothing.

## C O R O L L A R I E S *for Cubic Extractions.*

I. Hence in extracting Cube Roots, the Triple Square of the whole Quote is always the Divisor.

II. The Resolvend does always contain, or at least is $3aab+3abb+bbb$, or the Values express'd by these Letters.

III. The *Ablatitium* is always exactly $3aab+3abb+bbb$.

IV. From the Nature of the Punctations, and Order of Places, Unity in the Divisor will always stand under the Place of Hundreds in the Resolvend. I make use of no more for my Divisor than $3aa$, and thereby save some Labour; though all I ever yet saw add $3aa+3a$; but it comes all to one End.

Let $\overline{187237601}|^{\frac{1}{3}}$ be requir'd.

| | | |
|---|---|---|
| | 187237601 ( 572 | |
| | 125 | |
| $3aa$ . . 75 ) | 62237 | Resolvend. |
| | 343 . . . . | *bbb* |
| | 735 . . . . | $3abb$ |
| | 525 . . . . . | $3aab$ |
| | 60193 . . | Ablatit. |
| $3aa$ . . . 9747 ) | 2044601 | Resolv. |
| | 8 | *bbb* |
| | 684 | $3abb$ |
| | 19494 | $3aab$ |
| | 1956248 | Ablat. |
| | 88353 | Remaind. |

After pointing every third Figure from the left Hand, take the nearest Cube Root of the first Punctation, by the preceding Table, *viz.* 5. which set in the Quote, cub'd and subducted from 187, leaves 62; to which bring down 237, it makes 62237 for the Resolvend.

2. Triple square the Quote for a Divisor, *viz.* 5, which is 75. 5 will stand under 2, the place of Hundreds: So that 75 divides 622, and gives 7 for the Quote. Which cub'd, squar'd and multiply'd into the Triple of *a*, also multiply'd into the triple Square of *a*, gives the three Products, 343, 735, 525; which set in their proper places and added, give 60193, the Ablatitium; to be taken out of the Resolvend 62237, and there rests 2044; to which bring the next Punctation 601, it makes 2044601, a new Re-

3. Triple square the whole Quote 57; which makes 9747 for a Divisor to the new Resolvend as far as Hundreds; proceed as before, and there rests 68353, which shows that 187237601 contains a perfect Cube, and 88353 over and above: The Truth might be prosecuted in Decimals near, by adding Ternaries of Ciphers, *viz.* 000, and proceeding after the same manner for as many places as is required.

The proof of a Cubic Extraction is this, Take the Remainder, if any, and subtract it out of the Sum proposed to be extracted; then Cube the Quote, which will be equal to that Subtraction if true.

*Example.* The Cubic Root of 24489 is 29, and there remains 100; take this 100 out of 24489, there rests 24389 equal to the Cube of 29.

This Method of adding Decimals, gives but one Figure at a time in the Quote; and therefore may be much abridg'd by a *Converging Series*, which throws in 3, 6, or 12, at a time, if need be: The Method of which depends upon the Series in the following Extraction.

Let $\overline{aaa+b}|^{\frac{1}{3}}$ be demanded.

$$\begin{array}{l} aaa+b\left(a+\dfrac{b}{3aa}-\text{\&c.}\right. \\ aaa \\ \hline 3aa\left(b\right. \\ \quad b+\dfrac{bb.}{3a^3}+\dfrac{b^3}{27a^6} \\ \hline 3\times a+\dfrac{b}{3aa}\,\text{Sq.}\Big)-\dfrac{bb}{3a^3}-\dfrac{b^3}{27a^6} \end{array}$$

Let $a$ signify the nearest Root of the first Punctation, and $b$ the Remainder; Then this Series may be express'd in words thus. *If to the Cube Root (near) of the first Punctation be added, the Quote of the Remainder divided by the Triple Square of the first Quote, lessen'd by the Quote of the Sum of the Cube of the Quantity last placed in the Quote* + *3 Parallelipipedons, betwixt the Square of this last Quantity into Triple the rest of the Quote divided by the Triple Square of the whole Quote, repeated at pleasure, the Series arising shall, if infinitely continued, infinitely approach the true Value of any Cube Number.*

In the application of this to Numbers, great Care must be taken (as in the preceding Quadratic Series) of the Value of Places, because of adding and subtracting, and consequently finding the Place of each Figure arising in the Quote.

*Note.* This Method for Cubic Extractions is of little use, but when the Number given to be extracted is very large. I shall only give as small an Example as is practicable in this Method.

Let the *Cubic Root* of the mix'd Number 37.945 be demanded to four Places in Decimals, and the Operation will be as follows.

Such as please may, with a little more labour, throw yet more Decimals at a time in the Quote, if instead of the aforesaid Quadratic Series, they use $a+\dfrac{ab}{2aa+b}+$, *&c.* And if instead of the Cubic they use this $a+\dfrac{ab}{3aaa+b}+$, *&c.* Which two are found by taking as much of the second and third step in each Series together as may be conveniently done.

$$\begin{array}{l} \quad\ A \quad\ \ B \qquad\quad C \\ 37\ 245\ 000\ 000000000(3\ \dots\dots\ a \\ \ a \qquad b \qquad\qquad c \qquad\quad 3.7.\ \dots\dots\ b \\ \qquad\qquad\qquad\qquad\qquad\quad 3.37 \\ 27 \qquad\qquad\qquad\qquad\quad -00961\ \dots\ c \\ \hline 27)10.0(.37=b \qquad \text{All the Qu. } 33.6039- \\ \quad\ 81 \\ \hline \quad\ 190 \\ \quad\ 189 \\ \hline \qquad 1=\text{Rem.} \\ \hline .955000=\text{Rem.}+B \\ .050653=\text{Cube of Quantity last placed in the Quote.} \\ 1.2321\,..=\text{to its triple Square}\times a. \\ \hline \text{Triple the wh. Quote} \quad -1.282753\ \text{Ablatitium.} \\ \hline 34.0707)-.3277530(-00961=c \\ \qquad\qquad 3066363 \\ \hline \qquad\qquad 2111670 \\ \qquad\qquad 2044242 \\ \hline \qquad\qquad\ 67428=\text{Rem.} \end{array}$$

Another Operation would give all the Radical Figures, if the Sum propos'd was continued to eighteen more Places.

And in like manner the *Biquadratic*, *Cubiquadratick*, &c. *Roots* may be very briefly extracted.

I shall pass over the Business of mix'd or adfected Extractions, since that is much more conveniently perform'd by *Converging Series* as hereafter.

Re-

# *Reduction of Simple Equations.*

§. 1. AMongſt Quantities of different Values, there may be yet an Equality, as 40 *s.* $=$ 2 *l.* which may be repreſented in Letters at pleaſure; But becauſe in Algebraic Operations, known and unknown Quantities will be indifferently mix'd and complicated, therefore it will be convenient, for an eaſier diſtinction of them, to uſe different Characters, as $a$, $b$, $c$, $d$, &c. for ſuch as are known; and $x$, $y$, $z$, for ſuch as are unknown.

§. 2. When Quantities are thus mix'd, it's neceſſary ſo to *reduce* them, as that the *known* may poſſeſs one Side of the Equation, and the *unknown* the other. *Ex. gr.* $\frac{ab}{c} = x$; whence by comparing them together, the Value of the *unknown* may be diſcovered.

§. 3. Equation are of different Kinds, according as the Root of the reſpective Powers of the *unknown Quantity* is compounded, *viz.* *Simple* (or Lateral) *Quadratic*, *Cubic*, *Biquadratic*, or yet higher.

§. 4. In the Reſolution of *Simple* and *Quadratic Equations*, I ſhall make uſe of the common Methods, unleſs where the *Homogeneum Comparationis*, or *abſolutely known Quantity* is very great; in which Caſe (as well as in *Cubics*, *Biquadratics* and *higher Powers*) the new *Converging Series* is much preferable.

The *Reduction* of Simple Equations, which is firſt in order, may be effected, either

## By ADDITION.

§. 5. IF *equal Things be added to Equal, the Totals will be Equal.* Wherefore to get the unknown Quautity $x$ by its ſelf one ſide of the Equation,

Let there be propos'd, $\left.\begin{matrix}\\ \\ \end{matrix}\right\}$ Add $\begin{array}{c} x-a=b+c \\ \underline{a\,..\,a} \\ x=b+c+a \end{array}$ Add $\begin{array}{c} c-x=0 \\ \underline{x\,..\,x} \\ c=x \end{array}$ Add$\left\{\begin{array}{c} a+b-x=-gg \\ x\,.\,.\,.\,.\,x \\ \underline{gg\,.\,.\,.\,gg} \\ a+b+gg=x \end{array}\right.$

## By SUBTRACTION.

IF *equal things be taken from Equal, the Remainder will be Equal.* Ex. gr.

$$\begin{array}{rl} & x+a=b+c \\ \text{Sub.} & \underline{-a\,....\,-a} \\ & x=b+c-a \end{array} \qquad \begin{array}{rl} & dd+cc=qq+10+x+10d+\tfrac{1}{3} \\ \text{Sub.} & \underline{-q^2-10-10d-\tfrac{1}{3}\,...-q^2-10-10d+\tfrac{1}{3}} \\ & dd+cc-q^2-10-10d-\tfrac{1}{3}=x \end{array}$$

*Note.* Theſe two ways of Reduction, *viz.* by *Addition* and *Subtraction*, are compendiouſly perform'd by tranſpoſition of Quantities to the other Side of the Equation with contrary Signs; as in the preceding Examples.

$x-a=b+e$ Then, $x=b+c+a$ $\quad$ $ab-x=-gg$ Then, $ab+gg=x$ $\quad$ $dd+cc=qq-10+x+10d+\frac{1}{3}$ Then, $dd+cc-qq-100-10d-\frac{1}{3}=x$

F

By

## By Multiplication.

IF *equal Quantities be multiply'd by equal Quantities, the Products will be equal.*

Propose $\frac{x}{a}=b$ $\qquad \frac{x}{3d}=c$ $\qquad \frac{x}{bb+c}=rr$

Mult. by $a.\ \frac{ax}{a}=ab$ Mult. by $3d.\ \frac{3dx}{3d}=3dc$ Mult. by $bb+c.\ \frac{bbx+cx}{bb+c}=bbrr+crr$

That is $x=ab$ That is $x=3dc$ That is $x=bbrr+crr$

But in Practice only multiply the Denominator of the Fraction by the whole Number on the other side the Equation.

*Ex. gr.* $\frac{x}{3d}=c$, or $x=3dc$; And so of all others.

## By Division.

IF *equal Quantities be divided by equal Quantities, the Quotes will be equal.*

Propose $xx.=6x$ $\qquad dx+cx=qq$ $\qquad 16x-10=100$

That is $16x=90$

Div. by $x.\ \frac{xx}{x}=\frac{6x}{x}$ Div. by $d+c.\ \frac{dx+cx}{d+c}=\frac{qq}{d+c}$ Div. by $16.\ \frac{16x}{16}=\frac{90}{16}$

Or $x=6$ $\qquad$ Or $x=\frac{qq}{d+c}$ $\qquad$ Or $x=\frac{90}{16}$

Abbridg the Operation thus; Take all the Quantities, how many soever, that are multiply'd into the unknown Quantity (here) $x$, and by them divide the other side of the Equation.

*Ex. gr.* $dx+cx=qq$. Thus, $x=\frac{qq}{d+c}$. And so of all others.

In Simple Equations, the unknown Term $x$ is always clear'd by a contrary Operation: Therefore if it be multiply'd into a Quantity, divide both Parts of the Equation by that Quantity; If it be divided by a Quantity, multiply, &c.

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# *Reduction of* Equations *to Proportional Terms.*

SInce if four Quantities are proportional, the Product of the *extream Terms* is equal to that of the *middle*: From the Reverse hereof 'tis evident, that if an Equation can be so divided into four Parts, that the Product of the *Means* shall be equal to the Products of the Extreams, then such Parts are proportional Terms; wherein to make the thing useful, it will be convenient that the last Part (or fourth Term) be the unknown Number.

1. Observe, that if the Equation consist of whole Numbers, let that Quantity which is multiply'd into $x$, be the first Term.

Ex. $3abx=qq$ $\qquad$ If $dx+cx-bx=rrd$

Then $3ab.q::q.x.$ $\qquad$ Then $d+c+b\left\{\begin{matrix}rr\\r\end{matrix}\right\}::\left\{\begin{matrix}d\\rd\end{matrix}\right\}x$

2. Unity

2. Unity will be one of the Terms, if nothing else can be found.

Ex. $ax+b=r$ That is $ax=r-b$; then $a.1::r-b.x$

In affected Equations $xx+bx=d$. or $xx-d=bx$. then $b.xx-d::1.x$

3. In Fractions; If no other way presents it self, reduce them to Integers, and then work as before.

Ex. $\frac{xb}{c}=dd$. $\frac{b}{c}.d::d.x$. If it had been $\frac{xb}{c}=d$, then $xb=cd$. Whence again $b.c::d.x$.

These Methods are of great Use for expressing Algebraic Canons in Proportional Terms, and consequently for turning such Canons into Geometric Effections (if need be); also in finding the Tangents of Curves, and other useful Applications.

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## *The Resolution of* Simple Equations.

WHEN a Question is propounded, put $x$ for the unknown Number or Quantity sought, and work with it according to the Terms of the Question as if it were known, till an Equation be made; and then by some (or all) of the preceding Cases in Reduction, $x$ may be clear'd and possess only one Side of the Equation; and thus being equal to something that is known, its Value is also discover'd.

*Quest.* 1. The Sum of two Numbers is $s\ (=19)$ their Difference is $d\ (=9)$; What are the Numbers?

| | |
|---|---|
| 1. Put $x$ for the greater Number —— | $x$ |
| 2. Then the Lesser will be $s-x$ —— | $s-x$ |
| 3. Subtract the Lesser from the Greater to find their Difference, which is equal to $d$. —— | $-s+2x$ Or $2x-s=d$ |
| 4. Transpose $s$ —— | $2x=d+s$ |
| 5. Clear $x$ by Division —— | $x=\frac{d+s}{2}$ |

Whence this CANON, *Half the Sum and Difference of any two Numbers, is the greater Number.*

*Examen.* In Numbers $d=9$, and $s=19$ by Position; Then $\frac{9+19}{2}=14=x$

Therefore also the lesser Number is $19-14$, or 5.

But it's evident that 14 and 5 do satisfy the Question, for their Sum is 19, and their Difference is 9.

*Quest.* 2. The Product of two Numbers is $p\ (=100)$ their Difference is the greater Number lessen'd by 2. What are the Numbers?

The greater ——— $x$

The lesser ——— $\frac{p}{x}$

Their Difference is ——— $x - \frac{p}{x}$ or $\frac{xx-p}{x}$

The Equation ——— $\frac{xx-p}{x} = x - 2$

Which reduc'd to Integers, is ——— $xx - p = xx - 2x$

From each part subtract $xx$ ——— $-p = -2x$

Change the Signs, (the Equality will yet remain) and clear $x$ by Division — $x = \frac{p}{2} = 50$

Then the lesser will be $p$ divided by $\frac{p}{2}$, *viz.* 2.

The Numbers are 50 and 2, whose Product is 100, and whose Difference is $50 - 2$, or 48.

*Quest.* 3. The Ratio of two Numbers is $r$ to $s$, (3 to 2) their Difference is $d$ (8.) What are the Numbers.

The first Number ——— $x$

The second. $(r.s :: x.\frac{sx}{r})$ ——— $\frac{sx}{r}$

Their Difference is $x - \frac{sx}{r}$ or ——— $\frac{rx-sx}{r}$

The Equation ——— $\frac{rx-sx}{r} = d$

Multiply each Part by $r$ ——— $rx - sx = rd$

Divide each part by $r-s$ ——— $x = \frac{rd}{r-s}$

In Numbers $x = \frac{24}{3-2} = 24$ the first Number.

For the second, $3 . 2 :: 24 . \left(\frac{48}{3}\right)$ 16; the second Number: Which two will satisfy the Question.

## *A Collection of Questions for Exercising the preceding Rules.*

*Q.* 4. A Son asks his Father how old he was? Who answered, If from my Years thou takest 5, and dividest the Remainder by 8, the Quote will be $\frac{1}{3}$ of thy Years. But if to thy Years thou add 72, and multiply the Sum by 3, taking 7 from the Product, the Remainder is the Sum of my Years. How old was Father and Son?

*Q.* 5. Two Footmen travel, the first goes only six Miles every day, the other goes 10, but sets not out till eight Days after the first. In how many Days will the last overtake the first?

*Q.* 6. From *Norimberg* to *Rome* are 140 Miles. Two Travellers set out at the same Time from these two Cities, one travelling eight Miles every Day, the other Six; How long will they be before they meet; and how many Miles shall each have travelled?

*Q.* 7. A Captain sends forth $\frac{1}{3}$ of his Souldiers $+ 10$, and there remains with him $\frac{1}{2} + 15$; How many Souldiers has he in all?

*Q.* 8. To find the Side of a Square, whose *Area* shall be to the Sum of the Sides in a given Reason. Suppose $r$ to $s$, (45 to 12.)

*Q.* 9. To find the Side of a Cube, whose Surface shall be to its Solidity in a given Reason. Suppose $r$ to $s$, (6 to 12.)

*Q.* 10. A certain Vintner has two sorts of Wines, *A* and *B*: An equal Mixture of both is worth 15 *d.* a Bottle: But if they be so mix'd that three times the Quantity

tity of *A* be taken for two times the Quantity of *B*, the mixture will be worth 14 *d.* a Bottle.

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## *Of Questions by Diverse Positions.*

WHere Questions are answered by diverse Positions, so many unknown Quantities must be us'd as the Nature and Variety of the Question calls for. But before the Question can be resolv'd, all the unknown Terms must be destroy'd except one; Thus, Equate some one of the unknown Quantities to all the rest by Transposition; then instead of that Quantity, substitute what's equal to it in the following Equation, whereby it will vanish, and so destroy one by one, till only one remains. *Ex. gr.*

*Quest.* 1. To divide *A* into three parts $x, y, z$; So that $\begin{cases} 1.\ x+y=a \\ 2.\ y+z=b \\ 3.\ z+x=c \end{cases}$

Solution, 1. $x+y=a$. Whence $y=a-x$

By Subtract. 2. $a-x+z=b$. Whence $z=b-a+x$

3. $b-a+2x=c$. Whence $x=\dfrac{c+a-b}{2}$ Sought.

Again, 1. $\dfrac{c+a-b}{2}+y=a$ Whence $y=\dfrac{a+b-c}{2}$ Sought.

2. $\dfrac{a+b-c}{2}+z=b$. Whence $z=\dfrac{b+c-a}{2}$ Sought.

Otherwise (and sometimes more commodiously) the unknown Terms may be destroy'd by Addition or Subtraction. Let the same Question be repeated.

$$\left.\begin{array}{l} 1.\ x+y=a \\ 2.\ y+z=b \\ 3.\ z+x=c \end{array}\right\} \quad \begin{array}{rl} & 1.\ x+y=a \\ \text{Sub.} & 2.\ \underline{y+z=b} \\ & x-z=a-b \\ \text{Add} & 3.\ \underline{z+x=c} \\ & 2x=a+c-b \\ \text{Or,} & x=\dfrac{a+c-b}{2}\ \text{Sought.} \end{array}$$

$x$ being found, the other are easily found as before.

Multiplication or Division may help sometimes to destroy the unknown Terms, but very rarely.

There's yet another Method frequently made use of by Mr. *Oughtred*, in his *Opuscula Mathematica, viz.* putting one unknown Quantity for the Sum of all, which when discover'd, the parts are readily found out. Let the same Question be still propos'd.

$$\left.\begin{array}{l} 1.\ x+y=a \\ 2.\ y+z=b \\ 3.\ z+x=c \end{array}\right\} \&\ U=x+y+z \begin{cases} z=U-a \\ x=U-b \\ y=U-c \end{cases}$$
$$U=3U-a-b-c$$

And after Reduction $2U=a+b+c$. Or $U=\dfrac{a+b+c}{2}$ Sought.

Some of these Methods will never fail in all Cases that can happen in Questions of this Nature. I shall only add three or four for further Exercise.

*Q.* 2. The Husband, Son and Wife, make 96 Years: Thoſe of the Husband with his Son's are equal to the Wive's + 15. Thoſe of the Wife with the Son's, make the Husband's + 2. The Age of each is demanded?

*Q.* 3. To find three Numbers; So that the firſt with $\frac{1}{2}$ of the Remainder, the ſecond with $\frac{1}{3}$ of the Remainder; the third with $\frac{1}{4}$ of the Remainder, ſhall always make 34.

*Q.* 4. To find four Numbers, $u$, $x$, $y$, $z$. So that $u+x+y=z+b$. $x+y+z=u+c$. $y+z+u=x+d$.

*Q.* 5. To find three Numbers, $x$, $y$, $z$. So that $\frac{2}{3}x+\frac{1}{5}y=\frac{4}{5}y+\frac{1}{4}z=\frac{3}{4}z+\frac{1}{3}x$.

☞ *Note.* In this and the like Queſtions, it will much ſhorten the Work and eaſe the Difficulty, to reſolve all the Numbers into $x$, according to the Tenour of the Queſtion, and there will ariſe $x$, $\frac{5}{6}x=y$. and $\frac{2}{3}x=z$: Then take any Number for $x$, which may be divided by the Denominators of the Numbers reſolved in to $x$, *viz.* 6 and 3, and the Buſineſs is done. Let $x$ be 6, then is $y$ 5, and $z$ 4.

*Q.* 6. To find three Numbers $x$, $y$, $z$. So that $x+\frac{1}{3}y+\frac{1}{3}z=y+\frac{1}{4}z+\frac{1}{4}x=z+\frac{1}{5}x+\frac{1}{5}y$.

*Q.* 7. Two Numbers being given $b$ and $c$, to find a third $x$. So that $\overline{c+x}\times b$. $\overline{x+b}\times c$, and $\overline{b+c}\times a$, may decreaſe by an equal Interval.

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# *Of Indetermin'd Queſtions.*

If a Queſtion does not appear to be indetermined at firſt ſight, (which very ſeldom miſſes when 'tis ſuch) yet 'tis diſcoverable by this, if the Equation or Equations can be ſo tranſpos'd and varied, that the known Terms may be equated amongſt themſelves, (conſidering them as univerſal Quantities and not particular Numbers) then ſuch Queſtions are indetermin'd. For inſtance; Let

1. $z+y=a$. Whence $y=a-z$
2. $y+x=b$. Whence $y=b-x$ } Then $x=z-a+b$.
3. $x+u=c$. Whence $x=c-u=z-a+b$, & $z=a-b+c-u$.
4. $u+z=d$. Whence $z=d-u=a-b+c-u$, & $d=a-b+c$, all known.

But univerſal Quantities cannot be equal among themſelves, unleſs every Number was equal to every other Number, which is abſurd.

2. A Queſtion is alſo indetermin'd, which, when the Conditions are ſatisfied, does include two or more unknown Terms in the Equation, $ay=xx$: There may be innumerable Values of $y$ and $x$, and the Equation yet be true.

3. When there is not a mutual or reciprocal Habitude betwixt the two Terms in a Queſtion, ſuch Queſtion is undetermin'd. For Inſtance, *There are two Numbers, three times the greater is equal to the triple Square of the leſs.* If the Queſtion ſtays here 'tis indetermin'd, but if the ſecond Number does reciprocally affect the firſt, thus; *And twice the leſs is equal to half the greater*; or, *and the Sum, Difference,* &c. *of both is ſo*; then the Queſtion is determin'd, and admits but of one Anſwer. There might be other Rules laid done, but none (for any thing I yet ſee) which are not reducible to one of theſe Heads.

*Diophantus*, who by his prodigious Sagacity and Artifices in reſolving Queſtions of this Nature, has deſervedly perpetuated his Name, may be our Pattern in ſome Examples.

8. *c.* 2. *Dioph.* *Q.* 1. To divide a given Square $aa$ into two other Squares.

Let one of the ſought Squares be $xx$, (wheſe Side is $x$) then the other will be $aa-xx$, whoſe Side (any Arbitrary Number being taken, as $b$) let be $bx-a$; the Square of which is $bbxx-2bxa+aa-xx$; or $bbx-2ba=-x$, or $bba+x=2ba$:

Which

Which reduc'd, gives $x=\frac{2ba}{bb+1}$ the Side of one of the Squares sought. Which squar'd and subducted from the first given Square, leaves the other Square sought. This Resolution is of great use, for upon this depends the Invention of innumerable Sides and Varieties in a Right-angled Triangle.

10. *e.* 2. *Q.* 2. To divide $aa+bb$ into two other Squares, Let $a \sqsubset b$.

Assuming two Numbers at pleasure, $c \sqsubset d$. Let the side of the first Square be $ax-a$, and the side of the other $cx-b$; then proceed as in the last.

11. *e.* 2.] *Q.* 3. To find two square Numbers, whose Difference is $d$.

12. *e.* 2.] *Q.* 4. To find a Number, which added to $b$ and to $c$, shall make two Squares.

15. *e.* 2.] *Q.* 5. To divide $a$ into two such Parts, that if $aa$ be added to each, the Sums will be Squares.

21. *e.* 2.] *Q.* 6. To find two Numbers $x$ and $y$, so that $xx+y$, and $yy+x$ shall be square Numbers.

24. *e.* 2.] *Q.* 7. To find two Numbers $x$, $y$, so that $xx-x-y$, and $yy-y-x$, shall be square Numbers.

33. *e.* 2.] *Q.* 8. To find three Numbers, $x$, $y$, $z$. So that $xx+y$, and $yy+z$, and $zz+x$ shall be Squares.

1. *e.* 3. *Dioph.*] *Q.* 9. To find three Numbers, $x, y, z$. So that $x+y+z-xx$, and $x+y+z-yy$, and $x+y+z-zz$, shall be square Numbers.

9. *e.* 3.] *Q.* 10. To find three Numbers, $x$, $y$, $z$. So that both $x-y=y-z$; and yet the Sums of the three Numbers be all Squares.

18. *e.* 3.] *Q.* 11. To find three Numbers, $x$, $y$, $z$. So that both $xy+x+y$, and $x+y+z$, and $zx+z+x$ shall be Squares.

19. *e.* 3.] *Q.* 12. To find three Numbers, $x$, $y$, $z$. So that $xy-x-y$, and $yz-y-z$, and $yx-y-x$ shall be Squares.

*Q.* 13. If a Perpendicular be let fall from the opposite Side of a Right-angled Triangle, thereby dividing the whole into two other, similar and like the whole; 'tis demanded to give a Theorem to find innumerable Integers expressive of the Sides.

*Q.* 14. To find four more Right-angled Triangles in Integers, which shall have the same *Hypothenuse*.

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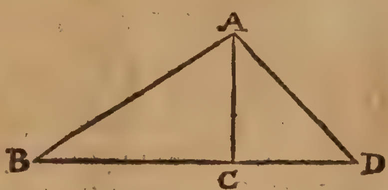
## *Questions producing Simple Equations in Geometry.*

I Shall only put a few of the easiest Questions here that I can light on, yet such as shall be introductive to higher, and exercise some of the most useful Propositions in *Euclid*, that assist us in the forming Equations.

*Quest.* 1. In a Triangle, ABD, all the Sides are given; the Segments of the Base (made by falling a Perpendicular from A) are sought.



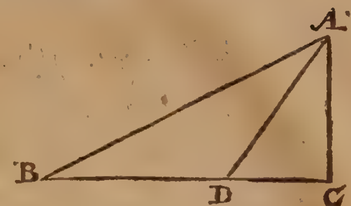

AB $=a$
BD $=b$
DA $=c$

$aa-yy=$ AC Square.
$cc-bb+2by-yy=$ AC Square. } 47. *e.* 1. *Eucl.*
Wheref. $aa-yy=cc-bb+2by-yy$, or $aa=cc-bb+2by$.

BC $=y$. CD $=b-y$ Whence $aa+bb-cc=2by$. Then $y=\frac{bb+aa-cc}{2b}$

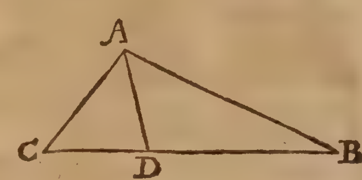
After the same manner putting CD $=x$, and BC $=b-x$, there arises $x=\frac{bb+cc-aa}{2b}$

*Quest.* 2. In any Obtuse-angled Triangle ABD, the three Sides being given, and either of the lesser BD, produc'd till it meet a Perpend AC, the extream Segment DC is required?




$AB = a$ $\quad aa - bb - 2bx - xx = ACq$ }
$BD = b$ $\quad cc - xx = ACq$ } 47. e. 1.
$DA = c$ Wheref. $aa - bb - 2bx - xx = cc - xx$, or $aa - bb - 2bx = cc$.
$DC = x$ Whence $aa - cc - bb = 2bx$, then $x = \frac{aa - cc - bb}{2b}$

*Quest.* 3. In any Triangle ABC, whose Angle at the top is equally bisected, the Sides AB, AC, with one of the Segments DB are given, the other Segment CD is required?

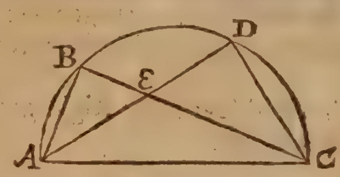



By 3. *e.* 6. AB. AC :: DB, CD, then $AB \times CD = AC \times DB$, then by Reduction.
$\frac{AC \times DB}{AB} = CD$ required.

*Quest.* 4. Two Triangles ABC, ADC, being given, standing upon the same Basis AC, to find the Segments EC, or BE?

The Angles at B and D are both right, by 31. *e.* 3. *Eucl.*
The opposite Angle BEA and DEC, are equal, (15. *e.* 1.)
Therefore the remaining Angles BAE, DCE are equal, (26. *e.* 1.)
Then the Triangles BEA, DEC, are similar and proportional, (4. *e.* 6.)

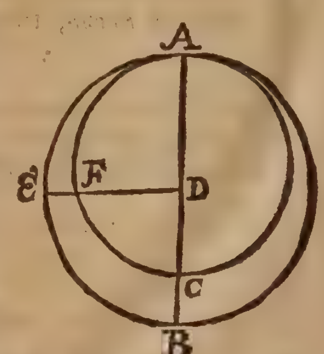
$AB = a$
$BC = b$
$CD = c$
$DA = d$
$EC = x$
$BE = b - x$.




Wherefore AB. CD :: BE. DE. and DC. CE :: AB. AE.
That is $a . c :: b - x . \frac{cb - cx}{a}$. and $c . x :: a . \frac{ax}{c}$

But $DE + AE = AD$; that is $\frac{cb - cx}{a} + \frac{ax}{c} = d$; which reduced, gives
$x = \frac{acd - ccb}{aa - cc} = EC$ required.

*Quest.* 5. Let there be a Circle, whose Diameter is AB, and another inscrib'd whose Diameter is AC, touching the first in A: Upon AB from the Center D, erect a Perpendicular ED; cutting the Periphery of the lesser Circle in F, there's given BC the Difference of the Diameters, with the Segment EF; the Diameters are demanded?




FD is a mean Proportional betwixt AD
$AD = x$ and DC, (13. *e.* 6.)
$EF = a$ Therefore $AD \times DC = FDq$, that is
$FD = x - a$ $\quad xx - bx = xx - 2ax + aa$.
$CB = b$ Which reduc'd, gives $x = \frac{aa}{2a - b} = AD$,

Whose double is the greater Diameter required; which lessened by $b$, gives the Lesser.

Of

# *Of* Surd Quantities.

*Notation of Surds.*

§. 1. WHEN the Root of any Quantity can't be truly expreſs'd, (according to any known Notation) ſuch Root is call'd a *Surd*, *Irrational*, or *Imperfect Root*, whether of a *Square Cube*, &c. Thus the Square Root of 18 is Imperfect; the next to it in whole Numbers is 4. The uſual way of this Notation, is to prefix a Note of Radicality, with the reſpective Index of the Power. For Inſtance, The Square Root of 18 is $\surd(2)18$: or $\surd 18$ the Biquadratic Root thereof is $\surd(4)18$: Or according to Dr. *Wallis* and Mr. *Newton*'s way of Notation, the Square Root of 18 is $\overline{18}|\frac{1}{2}$; the Square Root of $aa+bb$ is $\overline{aa+bb}|\frac{1}{2}$; the Cube Root of the Square Root of $aa+bb$ is $\overline{\overline{aa+bb}|\frac{1}{2}}|\frac{1}{3}$, or $\overline{aa+bb}|\frac{1}{6}$. The Biquadratic Root of the Cube of $a+b$, is $\overline{a+b}|\frac{3}{4}$; the Cube Root of $\frac{1}{2}q+\overline{\frac{1}{4}qq+\frac{1}{27}p^3}|\frac{1}{2}$, is $\overline{\frac{1}{2}q+\overline{\frac{1}{4}qq+\frac{1}{27}p^3}|\frac{1}{2}}|\frac{1}{3}$: And ſo of all others, $\frac{1}{4}$ being the Index of Radicality of the fourth Power, $\frac{1}{5}$ that of the fifth Power, &c.

In Fractions the Cubic Root of $\frac{a}{b}$ is $\surd(3)\frac{a}{b}$ or $\overline{\frac{a}{b}}|\frac{1}{3}$ or $\overline{\frac{a}{b}}\Big|\frac{\frac{1}{3}}{\frac{1}{3}}$, which laſt is the beſt way, where either the Numerator or Denominator are *perfect Powers*. Thus the Cubic Root of $\frac{20}{27}$ is $\frac{\overline{20}|\frac{1}{3}}{\overline{27}|\frac{1}{3}}$, that is $\overline{\frac{20}{3}}|\frac{1}{3}$, or the Cubic Root of 20 divided by 3. The Cubic Root of $\frac{a^3}{bb}$ is $\overline{\frac{a}{bb}}\Big|\frac{1}{3}$. The Square Root of $\frac{dd-e}{gg+bg+bb}$ is $\overline{\frac{dd-e}{g+b}}\Big|\frac{1}{2}$ &c.

*Reduction of Surds to lower Terms when poſſible.*

§. 2. All Surd Quantities may be expreſs'd as above; yet ſome are reduc'd into lower Terms by this Method. Divide the given *Surd* by the greateſt *Square*, *Cube*, *Biquadrate*, &c. contain'd therein, leaving no Remainder, (according to the Index thereof) and prefix the Root of ſuch Diviſor, whether *Square*, *Cube*, *Biquadrate*, &c. before the ſaid Surd, after the Method of Multiplication.

For Inſtance, $\surd 12$, divided by the greateſt Square in it, that leaves no Remainder; *viz.* 4 gives 3 in the Quote: Hence $\surd 12=2\surd 3$, (in the loweſt terms) for $\surd 4\times\surd 3=\surd 12$, but $\surd 4=2$; therefore $2\surd 3=\surd 12$. Thus $\surd 75=5\surd 3$; for $5=\surd 25$, and $25\times 3=75$. Thus alſo $\surd(3)40$, or $\overline{40}|\frac{1}{3}=2\surd(3)5$, or $2\times\overline{5}|\frac{1}{3}$. In Species $\surd a^3b=a\surd b$. $\surd\overline{a^3b-aabb+2aabc+abcc-ab^3+bbcc-2b^3c+b^4}=\overline{a+c}-b\surd\overline{ab+bb}$. $\surd\frac{48a^3b}{10}=4a\surd\frac{3ab}{10}$. $\surd\frac{aaoomm+4aamm}{ppzz}=\frac{am}{pz}\times\overline{\frac{oo+4}{1}}\Big|\frac{1}{2}$ or $\frac{am}{pz}\times\overline{oo+4}|\frac{1}{2}$. This Reduction is of very great uſe, becauſe the Values of Quantities are are more eaſily diſcovered in leſſer Terms than greater, alſo in the *Approximation of Roots*. For Inſtance, If $d=\surd\overline{aabb+aacc}$, then is $d=a\surd\overline{bb+cc}$; and dividing each part of the Equation by $a$, we have $\frac{d}{a}=\surd\overline{bb+cc}$, that is according to the Method of extracting Surd Quantities, $\frac{d}{a}=b+\frac{cc}{2b}-$, &c. Whereas if an

 immediate

immediately extraction had been made without Reduction, we should have had $d = ab + \frac{acc}{2b} -$ &c. which is more perplex'd and troublesome, especially if con-tinued to another Operation.

For the greater Ease in a reduc'd Notation of *Numeral Surds*, the following Table may properly be here inserted; whose Use is briefly thus. Opposite to $\sqrt{45}$ in the first Column is $3\sqrt{5} = \sqrt{45}$ in the lowest Terms, $\sqrt{288} = 6\sqrt{8}$ reduc'd. $\sqrt[3]{2560} = 8\sqrt[3]{5}$.

*A Table of Irrational Surds, reduc'd to lower Terms.*

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $\sqrt{6}$ | = | $2\sqrt{1\frac{1}{2}}$ | $\sqrt{75}$ | = | $5\sqrt{3}$ | $\sqrt{200}$ | = | $5\sqrt{8}$ | $\sqrt{486}$ | = | $9\sqrt{6}$ |
| $\sqrt{8}$ | | $2\sqrt{2\frac{1}{2}}$ | $\sqrt{80}$ | | $4\sqrt{5}$ | $\sqrt{216}$ | | $6\sqrt{6}$ | $\sqrt{490}$ | | $7\sqrt{10}$ |
| $\sqrt{10}$ | | $2\sqrt{2}$ | $\sqrt{90}$ | | $3\sqrt{10}$ | $\sqrt{243}$ | | $9\sqrt{3}$ | $\sqrt{500}$ | | $10\sqrt{5}$ |
| $\sqrt{12}$ | | $2\sqrt{3}$ | $\sqrt{96}$ | | $4\sqrt{6}$ | $\sqrt{245}$ | | $7\sqrt{5}$ | $\sqrt{512}$ | | $8\sqrt{8}$ |
| $\sqrt{18}$ | | $3\sqrt{2}$ | $\sqrt{98}$ | | $7\sqrt{2}$ | $\sqrt{250}$ | | $5\sqrt{10}$ | $\sqrt{539}$ | | $7\sqrt{11}$ |
| $\sqrt{20}$ | | $2\sqrt{5}$ | $\sqrt{99}$ | | $3\sqrt{11}$ | $\sqrt{252}$ | | $6\sqrt{7}$ | $\sqrt{467}$ | | $9\sqrt{7}$ |
| $\sqrt{24}$ | | $2\sqrt{6}$ | $\sqrt{108}$ | | $6\sqrt{3}$ | $\sqrt{275}$ | | $5\sqrt{11}$ | $\sqrt{600}$ | | $10\sqrt{6}$ |
| $\sqrt{27}$ | | $3\sqrt{3}$ | $\sqrt{112}$ | | $4\sqrt{7}$ | $\sqrt{288}$ | | $6\sqrt{8}$ | $\sqrt{640}$ | | $8\sqrt{10}$ |
| $\sqrt{28}$ | | $2\sqrt{7}$ | $\sqrt{125}$ | | $5\sqrt{5}$ | $\sqrt{294}$ | | $7\sqrt{6}$ | $\sqrt{648}$ | | $9\sqrt{8}$ |
| $\sqrt{32}$ | = | $4\sqrt{2}$ | $\sqrt{128}$ | = | $8\sqrt{2}$ | $\sqrt{300}$ | = | $10\sqrt{3}$ | $\sqrt{700}$ | = | $10\sqrt{7}$ |
| $\sqrt{40}$ | | $2\sqrt{10}$ | $\sqrt{147}$ | | $7\sqrt{3}$ | $\sqrt{320}$ | | $8\sqrt{5}$ | $\sqrt{704}$ | | $8\sqrt{11}$ |
| $\sqrt{44}$ | | $2\sqrt{11}$ | $\sqrt{150}$ | | $5\sqrt{6}$ | $\sqrt{343}$ | | $7\sqrt{7}$ | $\sqrt{808}$ | | $10\sqrt{8}$ |
| $\sqrt{45}$ | | $3\sqrt{5}$ | $\sqrt{160}$ | | $4\sqrt{10}$ | $\sqrt{360}$ | | $6\sqrt{10}$ | $\sqrt{810}$ | | $9\sqrt{10}$ |
| $\sqrt{48}$ | | $4\sqrt{3}$ | $\sqrt{162}$ | | $9\sqrt{2}$ | $\sqrt{384}$ | | $8\sqrt{6}$ | $\sqrt{891}$ | | $9\sqrt{11}$ |
| $\sqrt{50}$ | | $5\sqrt{2}$ | $\sqrt{175}$ | | $5\sqrt{7}$ | $\sqrt{392}$ | | $7\sqrt{8}$ | $\sqrt{1000}$ | | $10\sqrt{10}$ |
| $\sqrt{54}$ | | $3\sqrt{6}$ | $\sqrt{176}$ | | $4\sqrt{11}$ | $\sqrt{396}$ | | $6\sqrt{11}$ | $\sqrt{1100}$ | | $10\sqrt{11}$ |
| $\sqrt{63}$ | | $3\sqrt{7}$ | $\sqrt{180}$ | | $6\sqrt{5}$ | $\sqrt{405}$ | | $9\sqrt{5}$ | $\sqrt{1200}$ | | $10\sqrt{12}$ |
| $\sqrt{72}$ | | $3\sqrt{8}$ | $\sqrt{192}$ | | $8\sqrt{3}$ | $\sqrt{448}$ | | $8\sqrt{7}$ | | | |
| $2\sqrt{2}$ | = | $\sqrt{8}$ | $2\sqrt{5}$ | = | $\sqrt{20}$ | $2\sqrt{7}$ | = | $\sqrt{28}$ | $2\sqrt{10}$ | = | $\sqrt{50}$ |
| $3\sqrt{2}$ | | $\sqrt{18}$ | $3\sqrt{5}$ | | $\sqrt{45}$ | $3\sqrt{7}$ | | $\sqrt{63}$ | $3\sqrt{10}$ | | $\sqrt{90}$ |
| $4\sqrt{2}$ | | $\sqrt{32}$ | $4\sqrt{5}$ | | $\sqrt{80}$ | $4\sqrt{7}$ | | $\sqrt{112}$ | $5\sqrt{10}$ | | $\sqrt{160}$ |
| $5\sqrt{2}$ | | $\sqrt{50}$ | $5\sqrt{5}$ | | $\sqrt{125}$ | $5\sqrt{7}$ | | $\sqrt{175}$ | $5\sqrt{10}$ | | $\sqrt{250}$ |
| $6\sqrt{2}$ | | $\sqrt{72}$ | $6\sqrt{5}$ | | $\sqrt{180}$ | $6\sqrt{7}$ | | $\sqrt{252}$ | $6\sqrt{10}$ | | $\sqrt{360}$ |
| $7\sqrt{2}$ | | $\sqrt{98}$ | $7\sqrt{5}$ | | $\sqrt{245}$ | $7\sqrt{7}$ | | $\sqrt{343}$ | $7\sqrt{10}$ | | $\sqrt{490}$ |
| $8\sqrt{2}$ | | $\sqrt{128}$ | $8\sqrt{5}$ | | $\sqrt{320}$ | $8\sqrt{7}$ | | $\sqrt{448}$ | $8\sqrt{10}$ | | $\sqrt{640}$ |
| $9\sqrt{2}$ | | $\sqrt{162}$ | $9\sqrt{5}$ | | $\sqrt{405}$ | $9\sqrt{7}$ | | $\sqrt{567}$ | $9\sqrt{10}$ | | $\sqrt{810}$ |
| $10\sqrt{2}$ | | $\sqrt{200}$ | $10\sqrt{5}$ | | $\sqrt{500}$ | $10\sqrt{7}$ | | $\sqrt{700}$ | $10\sqrt{10}$ | | $\sqrt{1000}$ |
| $2\sqrt{3}$ | = | $\sqrt{12}$ | $2\sqrt{6}$ | = | $\sqrt{24}$ | $2\sqrt{8}$ | = | $\sqrt{32}$ | $2\sqrt{11}$ | = | $\sqrt{44}$ |
| $3\sqrt{3}$ | | $\sqrt{47}$ | $3\sqrt{6}$ | | $\sqrt{54}$ | $3\sqrt{8}$ | | $\sqrt{73}$ | $3\sqrt{11}$ | | $\sqrt{99}$ |
| $4\sqrt{3}$ | | $\sqrt{48}$ | $4\sqrt{6}$ | | $\sqrt{96}$ | $4\sqrt{8}$ | | $\sqrt{128}$ | $4\sqrt{11}$ | | $\sqrt{176}$ |
| $5\sqrt{3}$ | | $\sqrt{75}$ | $5\sqrt{6}$ | | $\sqrt{150}$ | $5\sqrt{8}$ | | $\sqrt{200}$ | $5\sqrt{11}$ | | $\sqrt{275}$ |
| $6\sqrt{3}$ | | $\sqrt{108}$ | $6\sqrt{6}$ | | $\sqrt{216}$ | $6\sqrt{8}$ | | $\sqrt{288}$ | $6\sqrt{11}$ | | $\sqrt{396}$ |
| $7\sqrt{3}$ | | $\sqrt{147}$ | $7\sqrt{6}$ | | $\sqrt{294}$ | $7\sqrt{8}$ | | $\sqrt{392}$ | $7\sqrt{11}$ | | $\sqrt{539}$ |
| $8\sqrt{3}$ | | $\sqrt{192}$ | $8\sqrt{6}$ | | $\sqrt{384}$ | $8\sqrt{8}$ | | $\sqrt{512}$ | $8\sqrt{11}$ | | $\sqrt{704}$ |
| $9\sqrt{3}$ | | $\sqrt{243}$ | $9\sqrt{6}$ | | $\sqrt{486}$ | $9\sqrt{8}$ | | $\sqrt{648}$ | $9\sqrt{11}$ | | $\sqrt{891}$ |
| $10\sqrt{3}$ | | $\sqrt{300}$ | $10\sqrt{6}$ | | $\sqrt{600}$ | $10\sqrt{8}$ | | $\sqrt{800}$ | $10\sqrt{11}$ | | $\sqrt{1100}$ |
| $2\sqrt[3]{2}$ | = | $\sqrt[3]{16}$ | $2\sqrt[3]{3}$ | = | $\sqrt[3]{24}$ | $2\sqrt[3]{4}$ | = | $\sqrt[3]{32}$ | $2\sqrt[3]{5}$ | = | $\sqrt[3]{40}$ |
| $3\sqrt[3]{2}$ | | 54 | $3\sqrt[3]{3}$ | | 81 | $3\sqrt[3]{4}$ | | 108 | $3\sqrt[3]{5}$ | | 135 |
| $4\sqrt[3]{2}$ | | 128 | $4\sqrt[3]{3}$ | | 192 | $4\sqrt[3]{4}$ | | 256 | $4\sqrt[3]{5}$ | | 220 |
| $5\sqrt[3]{2}$ | | 250 | $5\sqrt[3]{3}$ | | 375 | $5\sqrt[3]{4}$ | | 500 | $5\sqrt[3]{5}$ | | 625 |
| $6\sqrt[3]{2}$ | | 432 | $6\sqrt[3]{3}$ | | 648 | $6\sqrt[3]{4}$ | | 864 | $6\sqrt[3]{5}$ | | 1080 |
| $7\sqrt[3]{2}$ | | 686 | $7\sqrt[3]{3}$ | | 1029 | $7\sqrt[3]{4}$ | | 1372 | $7\sqrt[3]{5}$ | | 1715 |
| $8\sqrt[3]{2}$ | | 1024 | $8\sqrt[3]{3}$ | | 1536 | $8\sqrt[3]{4}$ | | 2048 | $8\sqrt[3]{5}$ | | 2560 |
| $9\sqrt[3]{2}$ | | 1458 | $9\sqrt[3]{3}$ | | 2187 | $9\sqrt[3]{4}$ | | 2916 | $9\sqrt[3]{5}$ | | 3645 |
| $10\sqrt[3]{2}$ | | 2000 | $10\sqrt[3]{3}$ | | 3000 | $10\sqrt[3]{4}$ | | 4000 | $10\sqrt[3]{5}$ | | 5000 |

Multi-

### *Multiplication of like Surd Roots.*

§. 3. The Reverſe of the preceding Method of reducing Integral Surds to lower Terms, furniſhes us with a Method of multiplying them. For Inſtance, $\sqrt{36} = 6\sqrt{1} = 6$, and $\sqrt{aa+2ab+bb} = a+b\sqrt{1} = a+b$, alſo $\sqrt{aa+baa} = a\sqrt{1+b}$, as is evident from the preceding Section; then it's alſo evident that the true Product of $a$ into $\sqrt{1+b} = a\sqrt{1+b} = \sqrt{aa+baa}$: And ſo of all other Homogeneal Roots. *Ex. gr.*

$$\begin{array}{ll} \text{Mult.} & \sqrt{10}+\sqrt{6} \\ \text{by} & \underline{\sqrt{10}+\sqrt{6}} \\ & \sqrt{100}+\sqrt{60} \\ & \qquad\quad \underline{\sqrt{60}+\sqrt{36}} \\ & \underline{\sqrt{100}+2\sqrt{60}+\sqrt{36}} \end{array}$$

$$\begin{array}{ll} \text{Which in} & \sqrt{10}+\sqrt{6} \\ \text{ſhorter} & \underline{\sqrt{10}+\sqrt{6}} \\ \text{terms is} & \underline{10+2\sqrt{60}+6} \\ \text{or} & \underline{16+2\sqrt{60}} \end{array}$$

$$\begin{array}{ll} \text{Mult.} & 3+\sqrt{2}-\sqrt{3} \\ \text{by} & \underline{3+\sqrt{2}+\sqrt{3}} \\ & 9+3\sqrt{2}-3\sqrt{3} \\ & \quad 3\sqrt{2}+2-\sqrt{6} \\ & \quad\quad \underline{+3\sqrt{3}+\sqrt{6}-\sqrt{3}} \\ \text{Prod.} & \underline{9+6\sqrt{2}+2-3} \\ \text{that is} & \underline{8+6\sqrt{2}.} \end{array}$$

$$\begin{array}{ll} \text{Mult.} & \sqrt{ab+\frac{d}{gg}}\Big|^{\frac{1}{2}}+\sqrt{\frac{d}{2}} \\ \text{by} & dd-\sqrt{\frac{2}{a}} \\ \text{Product,} & \underline{dd\sqrt{ab}+dd\sqrt{\frac{d}{gg}}+dd\sqrt{\frac{d}{2}}-\sqrt{2b}-\sqrt{\frac{2d}{agg}}-\sqrt{\frac{d}{a}}} \end{array}$$

### *Diviſion of like Surd Roots.*

§. 4. The preceding Method of reducing Fractional Surds, (§.2.) leads us to a Diviſion of them. For Inſtance, $\sqrt{\frac{drg+ss}{16}} = \frac{1}{4}\sqrt{\frac{drg+ss}{1}} = \frac{1}{4}\sqrt{drg+ss}$

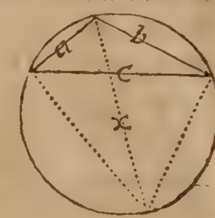
Therefore $\frac{1}{4}$ of $\sqrt{drg+ss}$, or $\sqrt{drg+ss}$ divided by 4, returns to what is was, *viz.* $\sqrt{\frac{drg+ss}{16}}$, or the Square Root of the Numerator divided by the Square Root of the Denominator.

$$\begin{array}{lll} \text{Thus } \sqrt{4-2d}\,\big) & \sqrt{4d+4gg+2dd-2dgg} & \big(\sqrt{d+gg} \\ & \underline{\sqrt{4d-2dd}} & \\ & \sqrt{\ *\ \ *\ \ 4gg-2dgg} & \\ & \qquad\ \ \underline{4gg-2dgg} & \end{array}$$

$$\begin{array}{lll} \text{Alſo } \sqrt{dd+g}\,\big) & \sqrt{2dd+dd\sqrt{dd}-\sqrt{3add}+g\sqrt{2}+gdd-g\sqrt{3a}} & \big(\sqrt{2}+dd-\sqrt{3a} \\ & \underline{\sqrt{2dd}} \qquad\qquad\qquad\qquad \underline{+g\sqrt{2}} & \\ & \quad dd\sqrt{dd}-\sqrt{3add}+gdd & \\ & \quad \underline{dd\sqrt{dd}} \qquad\qquad\quad \underline{+gdd} & \\ & \qquad -\sqrt{3add}-g\sqrt{3a} & \\ & \qquad \underline{-\sqrt{3add}-g\sqrt{3a}} & \end{array}$$

$$\begin{array}{lll} \sqrt{\frac{1}{3}d}\,\big) & 3dd\sqrt{\frac{1}{3}d}-\sqrt{\frac{1}{3}d\frac{2}{d}-\frac{a}{b}}-\sqrt{\frac{1}{3}dd+c} & \big(3dd-\sqrt{\frac{2}{d}-\frac{a}{b}}-\sqrt{d}+\sqrt{\frac{cc}{\frac{1}{4}d}} \\ & \underline{3dd\sqrt{\frac{1}{3}d}} & \\ & -\sqrt{\frac{1}{3}d}\sqrt{\frac{2}{d}-\frac{a}{b}} & \\ & \underline{-\sqrt{\frac{1}{3}}\sqrt{d\frac{2}{d}-\frac{a}{b}}} & \\ & -\sqrt{\frac{1}{3}dd} & \\ & \underline{-\sqrt{\frac{1}{3}dd}}+c \text{ or } \sqrt{\frac{cc}{\frac{1}{4}d}} \text{ Remainder.} & \end{array}$$

To ſhow the Neceſſity and great Uſe of the third and fourth preceding Sections; the former for freeing Equations from Surds, the latter for finding out the ſeveral Values of Roots in *Analytic Expreſſions*, &c. I ſhall give an Example or two, without proceeding to other Operations in Surds, my Deſign here being not to enlarge upon any Head, further than 'tis uſeful in Algebraic Practice, preſuming this ſufficient for that End; and ſuch as would know more of *Surds*, may peruſe Dr. *Wallis*'s *Treatiſe of Algebra*, cap. 25. who has writ the beſt on this Subject.




1. Suppoſe the three Sides of a Triangle $a$, $b$, $c$ were given given me, and the Diameter of a Circle $x$, in which the ſaid Triangle may be inſcrib'd, is demanded?

Since in any Quadrilateral inſcrib'd in a Circle, *the two Rectangles of the oppoſite Sides are equal to the Rectangle of the Diagonals.*

I have this Equation, $b\sqrt{xx-aa}+a\sqrt{xx-bb}=xc$.

By Tranſpoſition, $b\sqrt{xx-aa}=xc-a\sqrt{xx-bb}$

$$\underline{b\sqrt{xx-aa}} \qquad \underline{xc-a\sqrt{xx-bb}}$$

Each part ſquar'd, $bbxx-bbaa=xxcc-2xca\sqrt{xx-bb}+aaxx-aabb$

Equally expung'd, . . . . $xbb=xcc-2ca\sqrt{xx-bb}+aax$

Tranſpos'd, . . . . . . . . $2ca\sqrt{xx-bb}=xcc+aax-bbx$

Equally divided, . . . . . . $\sqrt{xx-bb}=\dfrac{xcc+aax-bbx}{2ca}$

$$\underline{\sqrt{xx-bb}}=\dfrac{xcc+aax-bbx}{2ca}$$

$$\begin{aligned}&x^2c^4+x^2a^2c^2-x^2ccbb\\&\qquad+x^2a^2c^2+a^4x^2-xxaabb\\&\qquad\qquad-x^2ccbb-xxaabb+b^4x^2\end{aligned}$$

Each part ſquar'd, . . . . . . . $xx-bb=\dfrac{x^2c^4+2x^2a^2c^2-2x^2c^2b^2+a^4x^2-2x^2a^2b^2+b^4x^2}{4ccaa}$

The Fraction clear'd, $4ccaaxx-4c^2a^2b^2=x^2c^4+2x^2a^2c^2-2x^2c^2b^2+a^4x^2-2x^2a^2b^2+b^4x^2$

By Tranſpoſition to make highest known Power poſitive. } $4ccaaxx-x^2c^4-2x^2a^2c^2+2x^2c^2b^2-a^4x^2+2x^2a^2b^2-b^4x^2=4c^2a^2b^2$

By common Reduction. } . $xx=\dfrac{4ccaabb}{2ccaa+2c^2b^2+2a^2b^2-c^4-a^4-b^4}$

Laſtly, If the Square Root of each part be extracted, we have the Diameter of the Circle required, *viz.*

$$x=\sqrt{\dfrac{4ccaabb}{2ccaa+2ccbb+2aabb-c^4-b^4-a^4}}$$

Or in lower Terms, $x=2cab\sqrt{\dfrac{1}{2c^2a^2+2c^2b^2+2a^2b^2-c^4-b^4-a^4}}$

2. Suppoſe in this Equation $xx+bx=d$, one of the Values of $x$ were given me, *viz.* $x=\sqrt{d+\frac{bb}{4}}-\frac{b}{2}$, and I am to find the other, (all Quadratics having two Roots, as will be ſhewed hereafter)

Then

$$\text{Then } x-\sqrt{d+\tfrac{bb}{4}}+\tfrac{b}{2}\Big)\,xx+bx-d\,\Big(x+\sqrt{d+\tfrac{bb}{4}}+\tfrac{b}{2}$$

$$\begin{array}{l} xx-x\sqrt{d+\frac{bb}{4}}+\frac{xb}{2} \\ \hline x\sqrt{d+\frac{bb}{4}}+\frac{xb}{2}-d \\ \hline x\sqrt{d+\frac{bb}{4}}-d-\frac{bb}{4}+\frac{b}{2}\sqrt{d+\frac{bb}{4}} \\ \hline \frac{xb}{2}+\frac{bb}{4}-\frac{b}{2}\sqrt{d+\frac{bb}{4}} \\ \frac{xb}{2}+\frac{bb}{4}-\frac{b}{2}\sqrt{d+\frac{bb}{4}} \\ \hline 0 \quad 0 \quad\quad 0 \end{array}$$

Whence alſo $x=-\sqrt{d+\frac{bb}{4}}-b$.

The ſame may alſo be done in Cubics.

## *Of Quadratic Equations.*

§. 1. WHatever may be reſolv'd into Parts, was firſt compounded of Parts, as $xx$ (ſuppoſing $x$ an Univerſal Quantity) was firſt made by the Multiplication of $x$ into its Self. Thus alſo $xxx$, was $xx$ before it could ariſe to be $xxx$; and ſo on *ad infinitum*. Whence it follows, that in any Equation whatever, there are ſo many Compoſitions or Values of $x$, as is the Index of the higheſt Power. For Inſtance, $xx+bx=d$; $x$ here has two Values. Again, in $xxx+bx=d$, there are three Values of $x$; and ſo in higher Equations.

§. 2. But from hence it does not follow that theſe Values are always Poſitive, for ſometimes they are *Negative*, ſometimes mix'd; ſometimes only *Imaginary*, or ſuch as include an impoſſibility in Nature, as will appear hereafter from their firſt Compoſition; and ſometimes one or two, or more of them may be the ſame, yet there will be always ſo many and no more, as is the Index of the higher Power: But how to determine *how many there are*, which *Poſitive*, which *Negative*, and which *Imaginary* in any Equation whatever, is beſt ſhew'd by their Origination.

§. 3. Let $x$ (as before) be an Univerſal Quantity, capable of expreſſing the Value of any effable or ineffable Number; and let the following Equations be made from the Alternation and *Values* of $x$.

1. $$\begin{array}{ll} x=b \;\ldots & x-b=0 \\ x=c \;\ldots & x-c=0 \\ \hline & \left.\begin{array}{l} xx-bx \\ \quad\;\, -cx+bc \end{array}\right\}=0 \end{array}$$

An Equat. of the third Form. $\left.\begin{array}{l}\\ \end{array}\right\} xx\begin{array}{l}-b\\-c\end{array}\Big\}\,x=-bc$

2. $$\begin{array}{ll} x=-b & x+b=0 \\ x=+c & x-c=0 \\ \hline & \left.\begin{array}{l} xx+bx \\ \quad\;\, -cx-bc \end{array}\right\}=0 \end{array}$$

An Equat. of the 1*ſt* or 2*d* Form. $\left.\begin{array}{l}\\ \end{array}\right\} xx\begin{array}{l}+b\\-c\end{array}\Big\}\,x=bc$

3. $$\begin{array}{ll} x=-b & x+b=0 \\ x=-c & x+c=0 \\ \hline & \left.\begin{array}{l} xx+bx \\ \quad\;\, +cx+bc \end{array}\right\}=0 \end{array}$$

An Imaginary Equation. $\left.\begin{array}{l}\\ \end{array}\right\} xx+\begin{array}{l}b\\c\end{array}\Big\}\,x=-bc$

1. Whence we may obſerve, that an Equation of the third Form (ſuppoſing $\begin{array}{l}-b\\-c\end{array}$ made one Quantity, as alſo $bc$) has always two poſitive Roots or Values of $x$.

2. An Equation of the *firſt* or *ſecond* Form, has always two Roots: Let $\begin{array}{l}+b\\-c\end{array}$ be made one Quantity; and if $+b$ prevails, or if the Equation be of the firſt Form, the greater Root is Negative, and the leſſer Poſitive. If the Equation be of the ſecond Form, (or if $-c$ prevailes) the greater Root is Poſitive, and the leſſer Negative; and if both the Roots be equal, the ſecond Root will be deſtroy'd.

The three Forms being put in their moſt Simple Terms, appear thus with their different Roots.

Third Form, $xx - bx = -d$ $\begin{cases} x = \sqrt{\frac{bb}{4} - d} + \frac{b}{c} & \text{Greater Root Poſitive.} \\ x = \frac{b}{2} - \sqrt{\frac{bb}{4} - d} & \text{Leſſer Root Poſitive.} \end{cases}$

Firſt Form, $xx + bx = d$ $\begin{cases} x = -\frac{b}{4} - \sqrt{d + \frac{bb}{4}} & \text{Greater Root Negative.} \\ x = \sqrt{d + \frac{bb}{4}} - \frac{b}{4} & \text{Leſſer Root Poſitive.} \end{cases}$

Second Form, $xx - bx = d$ $\begin{cases} x = \sqrt{d + \frac{bb}{4}} + \frac{b}{2} & \text{Greater Root Poſitive.} \\ x = \frac{1}{2}b - \sqrt{d + \frac{bb}{4}} & \text{Leſſer Root Negative.} \end{cases}$

3. The third and laſt Multiplication of the two Negative Values of $x$, exhibit an *imaginary or impoſſible Equation*; for two Poſitive Quantities can't be equal to a Negative one: Therefore I ſhall paſs over the Roots as expreſs'd in the other three preceding *Forms*, becauſe uſeleſs.

4. The Coefficient of (or Quantity affecting) the ſecond Term, in the firſt and ſecond Form, is the Difference of the two Roots, (under a contrary Sign) according as the Negative or Poſitive prevails; and in the third Form 'tis the Sum of the two Roots under a contrary Sign.

5. *The Homogeneum Comparationis*, as *Vieta* calls it, or *abſolute known Quantity* that poſſeſſes one Side of the Equation, is equal to a Rectangle of the two Roots, both multiply'd under the ſame Sign in every Form.

6. In the third Form the Coefficient is always greater than any of the two Roots: And if a Quarter of the Square of the whole Coefficient be equal to the *abſolute known Number*, the two Roots are both of the ſame Value, or elſe not.

6. If in the firſt and ſecond Form, the two Roots are of the ſame Value, the ſecond Term will be deſtroyed.

7. Laſtly, Suppoſing the whole Equation made equal to o, ſo often as + follows —; or the contrary, ſo many Affirmative Roots there in that Equation: and ſo often as + follows +, and — follows —, ſo many are the Negative Roots, at leaſt *real Ones*, for the Imaginary I paſs over as uſeleſs.

§. 4. We are firſt to *order* and *prepare an Equation*, before we extract the Roots thereof, the Method may be fully and briefly compris'd under theſe Rules.

1. If the higheſt unknown Power be Negative, change all the Signs, (the Equation is not deſtroy'd) becauſe 'tis impoſſible for a Negative Square to have any Root, ſince $+\times+$ gives $+$, and $-\times-$ gives $+$. For Inſtance, If $bx - xx = d$, then is $-bx + xx = -d$.

2. If the higheſt unknown Power be not firſt in Order, make it ſo, becauſe the Extraction muſt begin therewith; thus $-bx + xx = -d$, becomes $xx - bx = -d$.

3. If the higheſt unknown Power be affected with any Coefficient, it muſt be clear'd either by Diviſion or Multiplication.

For Inſtance, If $cxx + bx = d$, then $xx + \frac{b}{c}x = \frac{d}{c}$. If $\frac{xx}{c} + bx = d$, then $xx = bcx - cd$.

4. If there be no Coefficient to the ſecond Term, Unity ſupplies the place, Ex. gr. $xx + x = d$, then is $xx + 1x = d$.

5. If there be more Coefficients to the ſecond Term than one, they muſt be all reduc'd to one.

For Example, If $xx + bx + cx - \frac{d}{r}x = p$, then $xx + \overline{b + c - \frac{d}{r}}\,x = p$.

§. 5. When

§. 5. When an Equation is prepar'd and ordered as above, the Roots of them (which I have already ſet down, with their reſpective Forms, for a greater convenience of comparing them with their Original Formations) may be extracted by ſeveral Methods; One of which may be this.

Put $y$ (an unknown Quantity + or —, the Coefficient of the ſecond Term, (taking always a contrary Sign) divided by the Index of the higheſt unknown Power, as 2 in the Square, 3 in the Cube, 4 in the Biquadrate, &c. And by this Artifice the ſecond Term will be deſtroy'd, if a new Equation be made anſwerable to the reſpective Parts of the firſt. For Inſtance,

1. Let $xx+bx=d$, and let $y-\frac{1}{2}b=x$.
2. Then $yy-yb+\frac{1}{4}bb=\left\{\begin{matrix}xx\\ bx\end{matrix}\right\}=d$
3. Alſo . . . $yb-\frac{1}{2}bb=$
4. Where $yy-\frac{1}{4}bb=\!=\!=\!=d.$
5. By Tranſp. $yy=d-\frac{1}{4}bb.$
6. By equal Extract. $y=\sqrt{d-\frac{1}{4}bb}$
7. * But $x+\frac{1}{2}b\,(=y)=\sqrt{d+\frac{1}{4}bb}$
8. Then alſo $x=\sqrt{d+\frac{1}{4}bb}-\frac{1}{2}bb$

* If $y-\frac{1}{2}b=x$
Then $y-x=\frac{1}{2}b$

Reaſſuming the ſeventh Step, where $x+\frac{1}{2}b=\sqrt{d+\frac{1}{4}bb}$. Square each part of the Equation, there ariſes $xx-xb+\frac{1}{4}bb=d+\frac{1}{4}bb$. Whence we have alſo another Method for reſolving Quadratic Equations, *by adding $\frac{1}{4}$ of the Square of the whole Coefficient to both Sides of the Equation,* thereby making the firſt Part a true Square, and conſequently capable of an exact Extraction. Thus alſo in an Equation of the *ſecond Form,* $xx-\frac{bx}{c}=d$, by adding to each ſide $\frac{bb}{4cc}$ ($\frac{1}{4}$ of the Square of $\frac{b}{c}$) there ariſes $xx-\frac{b}{c}x+\frac{bb}{4cc}=d+\frac{bb}{4cc}$, and by extracting the Roots of both Sides, $x-\frac{b}{2c}=\sqrt{d+\frac{bb}{4cc}}$, and by tranſpoſing of $\frac{b}{2c}$, $x=\sqrt{d+\frac{bb}{4cc}}+\frac{b}{2c}$. And laſtly, In the third Form, $xx-\overline{b-c}\,x=-d$; then by adding a quarter of the Square of the whole Coefficient to each Side of the Equation, we have $xx-\overline{b-c}\,x+\frac{bb+2cb+cc}{4}=\frac{bb+2bc+cc}{4}-d$; And by equal Extraction of Roots, $x\frac{-b-c}{2}=\sqrt{\frac{bb+2cb+cc}{4}-d}$, and by Tranſpoſition $x=\sqrt{\frac{bb+2d+cc}{4}-d}+\frac{b+c}{2}$.

§. 6. Having diſcovered one of the Roots of any one of the three Forms, the other may be found by Diviſion, as was ſhewed before in the Diviſion of *Surds.* Let it be propoſed to find the ſecond Root in the *third Form,* the firſt being given in the Equation, $xx-bx=-d$, *viz.* $\sqrt{\frac{dd}{4}-d}+\frac{b}{2}$; Then alſo by Tranſpoſition $x-\sqrt{\frac{dd}{4}-d}-\frac{b}{2}=0$; Alſo $xx-bx+d=0$, and *this* divided by *that*, exhibits the following Operation, the Quote of which is equal to Nothing; for if 0 divides 0, 0 will reſult: Then by Tranſpoſition, the ſecond Root is found, $x=\frac{b}{2}-\sqrt{\frac{bb}{4}-d}$. Which is alſo Poſitive, and 'tis the third Form only that has two Poſitive Roots, and which are ſo ambiguous in many Algebraic Operations, that till we have tried both, 'tis difficult to know which is the moſt proper Solution of a Queſtion, but in the other two Forms this Difficulty never occurs, but the enquired Root comes firſt.

$$x-\sqrt{\frac{bb}{4}-d}-\frac{b}{2}\Big)\,xx-bx+d\,\Big(\,x+\sqrt{\frac{bb}{4}-d}-\frac{b}{2}=0$$

$$xx-x\sqrt{\frac{bb}{4}-d}-\frac{xb}{2}$$

$$x\sqrt{\frac{bb}{4}-d}\;\frac{xb}{2}+d$$

$$x\sqrt{\frac{bb}{4}-d}-\frac{bb}{4}+d-\frac{b}{2}\sqrt{\frac{bb}{4}-d}$$

$$-\frac{xb}{2}+\frac{bb}{4}+\frac{b}{2}\sqrt{\frac{bb}{4}-d}$$

$$-\frac{xb}{2}+\frac{bb}{4}+\frac{b}{2}\sqrt{\frac{bb}{4}-d}$$

There's yet another way of finding the two Roots at once.

Let the Sum of the two Roots be $2p$, and their Difference $2q$, then is the greater Root $p+q$, and the lesser $p-q$; then also is $x-p-q=0$, and $x-p+q=0$. Multiply for a new Equation.

$$\begin{array}{r} x-p-q \\ x-p+q \\ \hline xx-xp-xq \\ -xp+pp+pq \\ -qx-pq-qq \\ \hline xx-2px+pp-qq=0 \\ xx+bx-dd\ =\ 0 \end{array}$$

Compare the Product with any of the three Forms. Suppose with the first, $xx$ and $xx$ destroy each other, and there are yet these two Equations of the Parts $-2px=bx$, and $pp-qq=-d$. The first Equation is reduced to $-2p=b$; divide each part by 2. $-p=\frac{1}{2}b$. Wherefore also $pp=\frac{bb}{4}$. Which substitute in the Room of $pp$ in the second Equation, and there arises $\frac{bb}{4}-qq=-d$; or by Transposition $\frac{bb}{4}+d=+qq$; and by equal Extraction $\sqrt{\frac{bb}{4}+d}=+q$; therefore the two Roots will be found at once, *viz.* the greater $p+q=-\frac{1}{2}b+\sqrt{\frac{bb}{2}+d}$, the lesser $p-q=-\frac{1}{2}b-\sqrt{\frac{bb}{4}+d}$. The same Method may be pursued in the other two Cases.

§. 7. There are yet Biquadratics, as also higher Equations belonging to the three preceding Forms, which are of the same Nature as Quadratics, and may not improperly receive their Solution here.

| | |
|---|---|
| *The first Form* ———— | $xxxx+bxx=d$ |
| The Positive Root ———— | $xx=\sqrt{d+\frac{bb}{4}}-\frac{b}{2}$ |
| A second Extraction ———— | $x=\left.\sqrt{d+\frac{bb}{4}}-\frac{b}{2}\right\vert^{\frac{1}{2}}$ |
| *The second Form* ———— | $xxxx-bxx=d$ |
| The Positive Root ———— | $xx=\sqrt{d+\frac{bb}{4}}+\frac{q}{2}$ |
| A second Extraction ———— | $x=\left.\sqrt{d+\frac{bb}{4}}+\frac{b}{2}\right\vert^{\frac{1}{2}}$ |
| *The third Form* ———— | $xxxx-bxx=-d$ |
| The greater Positive Root ——— | $xx=\sqrt{\frac{bb}{4}-d}+\frac{b}{2}$ |
| A second Extraction ———— | $x=\left.\sqrt{\frac{bb}{2}-d}+\frac{bb}{2}\right\vert^{\frac{1}{2}}$ |

These three Forms in Biquadratics occur pretty often; and the same Solution would hold for any higher Power thus qualified.

For

For Instance, $x^6 + bx^3 = d$, the Root of which is $xxx = \sqrt{d + \frac{bb}{4}} - \frac{b}{2}$, and by extracting the Cube Root of each, $x = \overline{\sqrt{d + \frac{bb}{4}} - \frac{b}{2}}\Big|^{\frac{1}{3}}$.

Thus also if $x^{20} + bx^{10} = d$, then is $x = \overline{\sqrt{d + \frac{bb}{4}} - \frac{b}{2}}\Big|^{\frac{1}{10}}$. And so of all others thus qualified, *ad infinitum.*

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## *Numeral Questions falling under Quadratic Equations.*

*Q.* 1. CLAVIUS in his Treatise of Algebra, (*Cap.* 31. *Quest.* 58.) puts this Question; Two Persons have each a certain number of Crowns; the Sum of which being subducted from the Sum of the Squares of the said Numbers (made separately) leaves 78; but their Sum being added to the Product of the two Numbers, gives 39. 'Tis demanded how many Crowns each had?

This Question, says *Clavius*, is too difficult to be answer'd by Algebra, without very good knowledg in Geometry. But Algebra is now brought to that Perfection, that Geometry depends rather upon it, than it does upon Geometry, since we are not only able to resolve such Questions by pure Algebra, as no Geometrician can do by Rule and Compass, but also to find out Laws and Rules for several *Geometric Effections*, which otherwise would be desperate.

But to return from this Digression. Let $2y$ be the Sum of the unknown Numbers, and $2z$ their Difference, and let $78 = a$, and $39 = b$; then $y+z$ the greater Number, and $y-z$ the Lesser. Hence,

| | |
|---|---|
| 1. The Sum of their Squares is —— | $2yy + 2zz$. |
| 2. *Idem*, lessened by their Sum, $= a$ | $2yy + 2zz - 2y = a$. |
| 3. Clear $zz$ —————— | $zz = y + \frac{1}{2}a - yy$. |
| 4. Their Product added to their Sum $= b$ —————— | $yy - zz + 2y = b$. |
| 5. Clear $zz$ —————— | $zz = yy + 2y - b$. |
| 6. From the 3*d* and 5*th* Steps —— | $y + \frac{1}{2}a - yy = + yy + 2y - b$. |
| 7. By Reduction —————— | $yy + \frac{1}{2}y = \frac{2b+a}{4}$ |
| 8. Add to each $\frac{1}{4}$ of the Square of the whole Coeffement —— | $yy + \frac{1}{2}y + \frac{1}{16} = \frac{2b+a}{4} + \frac{1}{16}$. |
| 9. Extract equally —————— | $y + \frac{1}{4} = \sqrt{\frac{2b+a}{4} + \frac{1}{16}}$. |
| 10. Transpose $\frac{1}{4}$ —————— | $y = \sqrt{\frac{2b+a}{4} + \frac{1}{16}} - \frac{1}{4}$. |

Which is in Numbers $\sqrt{\frac{78+78}{4} + \frac{1}{16}} - \frac{1}{4}$ or $\sqrt{39\frac{1}{16}} - \frac{1}{4} = \sqrt{\frac{625}{16}} - \frac{1}{4} = 6$. therefore 12 is the Sum of the two Numbers, and from Step 4. $36 - zz + 12 = 39$; that is $zz = 9$, then is $z = 3$; but the greater was $y+z$ by Supposition, therefore $6 + 3 = 9$ the greater Number, $6 - 3 = 3$ the lesser Number sought: Which two will answer the Conditions of the Question.

 *Q.* 2.

*Q.* 2. The Mean of the three Geometric Proportionals being given (12), and the Sum of their Extreams (26); to find the three Numbers, let $m$ be the Mean; $2s$ the Sum of their Extreams, and $2y$ the Difference of their Extreams, then is the greater $s+y$, and the lesser $s-y$. Whence $\overline{s+y} . m . \overline{s-y} \div$, that is $ss-yy=mm$; whence $ss-mm=yy$, then is $y=\sqrt{ss-mm}$, that is $\sqrt{13\times13-12\times12}=5$; and by Position $y$ or 5 is half the difference of their Extreams; but half the Sum and half the Difference of two Numbers is always the greater; so that 18 is the greatest. Whence $18 . 12 . (12) . 8 \div$ are the three Numbers sought.

*Q.* 3. The Product of two Numbers is $p$, and the Sum of their Squares is $q$; What are the Numbers?

For their Sum put $2x$, and for their Difference $2y$; then is $x+y$ the greater Number, and $x-y$ the Lesser; their Product is $xx-yy=p$, and the Sum of their Squares is $2xx+2yy=q$. In the first Equation $xx-p=yy$, in the $2^d$, $\frac{1}{2}q-xx=yy$; Therefore $xx-p=\frac{1}{2}q-xx$; or $2xx=\frac{1}{2}q+p$; or $xx=\frac{1}{4}q+\frac{1}{2}p$; or $x=\sqrt{\frac{1}{4}q+\frac{1}{2}p}$: Then $\sqrt{\frac{1}{4}q+\frac{1}{2}p}$, is half their Sum, and half their Difference is given, by consequence the Numbers themselves.

Or shorter thus, with one unknown Quantity; Let your Product be $p$, the Sum of their Squares $2q$, and the Difference of their Squares $2y$. Then is $\overline{q+y}$ the greater Square, and $\overline{q-y}$ the Lesser; the Product of whose Roots, *viz.* $\sqrt{q+y}\times\sqrt{q-y}=p$, that is, $\sqrt{qq-yy}=p$, and to clear the Surd $qq-yy=pp$. Whence as before, $y=\sqrt{qq-pp}$, which is half the Difference of their Squares; but half the Sum and half the Difference of two Squares being given, the Squares themselves are given, and by consequence the Roots.

If it be demanded why I make use of $x+y$ for the greater unknown Number, and $x-y$ for the Lesser, and not rather $x$ for the Greater, and $y$ for the Lesser: I answer, That by this Method, in twenty Quadratics together, if work'd according to Mr. *Kersey*'s Method and his Followers, I avoid for the most part the second Term, which they cannot, and thereby save much Labour. Besides such Questions as by this Method do arise to an affected Quadratic, are commonly extreamly difficult, if resolv'd according to the ordinary way: Nay even a simple Quadratic in this Method will sometimes resolve what's very troublesom in that, as may be seen by some of the following Questions.

*Q.* 4. The Sum of the Extreams of four Numbers in Geometric Proportion, and the Sum of the Means being given to find each of the Terms.

Put $2a$ for the Sum of the Extreams, and $2x$ for their Difference, $2b$ the Sum of the Means, and $2y$ their Difference, and proceed, *&c.*

*Q.* 5. The Sum of the Squares of two Magnitudes, and the Ratio of their Product to the Square of their Difference being given, to find the Numbers?

*Q.* 6. The Product of two Numbers, with the Sum of their Cubes, to find the Numbers?

*Q.* 7. The Square of two Numbers, with the Sum of their Cubes being given, to find the Numbers?

*Q.* 8. The Difference of the Squares of two Numbers being given, with the Difference of their Cubes, to find the Squares?

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*For*

## *For forming Equations in any* Arithmetical *or* Geometrical Progreſſion.

§. 1. IN any *Arithmetical Progreſſion*, Let $a$ be the firſt Term, $\omega$ the laſt, $n$ the Number of Terms, $s$ the Sum of all the Terms, and $d$ the Common Difference.

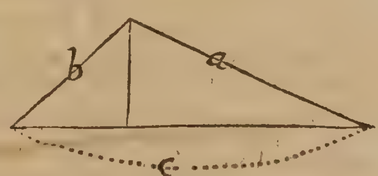
*Lemma* I. $\omega = a + d \times \overline{n - 1}$.
*Lemma* II. $s = \frac{1}{2} n \times \overline{a + \omega}$.

Any three of theſe being given, as $a + \omega + s$, or $d + n + s$, &c. the other two are alſo given: And of theſe Threes there may be ſixty Alternations; which expunging ſuch as are alike, are reduc'd to twenty Caſes by Mr. *Oughtred*; and may be all eaſily reſolv'd by the preceding *Lemma's*.

§. 2. In any *Geometrical Progreſſion*, Let $a$ be the firſt Term (or Antecedent); $b$ the 2d Term or Conſequent, $s - \omega$ the Sum of all the Antecedents, and $s - a$ the Sum of all the Conſequents. Then as $a . b :: s - \omega, s - a$, or $as - aa = bs - b\omega$, or $as - bs = aa - b\omega$; whence $s = \frac{aa - b\omega}{a - b}$ if the Progreſſion decreaſes; or elſe $s = \frac{b\omega - aa}{b - a}$, when it increaſes.

## *Of Quadratic Equations in Geometry.*

*Q.* 1. LET the three Sides of any Triangle, $a$, $b$, $c$, be given; to find the length of a Perpendicular let fall upon the Baſe.




From the preceding firſt Theorem in Simple Equations;

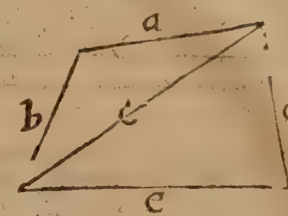
$\frac{cc + bb - aa}{2}$ = to the leſſer Segm. of the Baſe. Whence according to the new way of Notation, $bb - \overline{\frac{cc + aa - bb}{2c}}\Big|^{\frac{2}{1}}$, is equal to the Square of the Perpendicular; whoſe Root $\sqrt{\overline{bb - \overline{\frac{cc + bb - aa}{2c}}\Big|^{\frac{2}{1}}}}$, is the Perpendicular ſought.

From hence alſo we have this Theorem for the *Areas* of Triangles (3 Sides being given) *viz.* $\frac{1}{2} c \sqrt{\overline{bb - \overline{\frac{cc + bb - aa}{2c}}\Big|^{\frac{2}{1}}}}$.

Or in a little ſhorter Terms, $\frac{1}{2} c \sqrt{\overline{bb - \overline{\frac{1}{2} c + \frac{bb - aa}{2c}}\Big|^{\frac{2}{1}}}}$.



Hence




Hence alſo we have a *Theorem* for the meaſuring of *Trapezias*, whoſe four Sides are given, with the Diagonal, *viz.*

$$\tfrac{1}{2}c\sqrt{bb-\overline{\tfrac{1}{2}c+\frac{bb-a}{2c}}\Big|^{\frac{2}{1}}}+\tfrac{1}{2}c\sqrt{dd-\overline{\tfrac{1}{2}c+\frac{dd-ee}{2c}}\Big|^{\frac{2}{1}}}$$

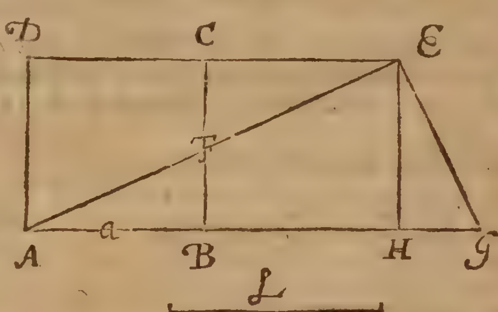
Equal to the *Area* of any *Trapezium*, *a*, *b*, *c*, *d*, *e*, or to avoid two Multiplications.

$$\tfrac{1}{2}c\sqrt{bb-\overline{\tfrac{1}{2}c+\frac{bb-aa}{2c}}\Big|^{\frac{2}{1}}+\sqrt{dd-\overline{\tfrac{1}{2}c+\frac{dd-ee}{2c}}\Big|^{\frac{2}{1}}}}$$

ſhall be the *Area* thereof. This is a very exact way in caſe of any Diſpute; for the ſurveying any large Plains, Fields, Commons, *&c.* which are very eaſily reduced into *Trapezias*.

But the ſhorteſt *Theorem* that can poſſibly be given for the *Areas* of Triangles, is that of Mr. *Oughtred*, provided the literal Expreſſion be not delivered at length as it has been by him, Mr. *Kerſey* and others. The known Terms ariſing to Surſolids, I would chuſe to expreſs it thus, reſuming the firſt Triangle, and putting $s$ for half the Sum of the three given Sides, $a, b, c$, viz. $\sqrt{s \times s-a \times s-b \times s-c}$, equal to the *Area* of any Triangle, as $a, b, c$.

*Q.* 2. There's a Square given, A B C D; and it's demanded to draw a Line C E, to meet A B produc'd. So that the External Part F E, ſhall be equal to a given Line L.

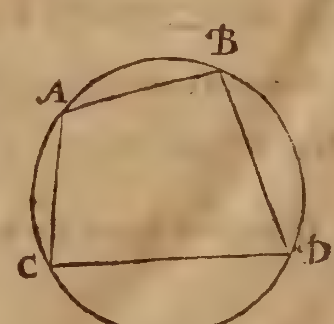



Produce A B indeterminately, as alſo D C, and draw E G perpendicular to A E, and E H perpendicular to A G.

$$\text{Let}\left.\begin{array}{l} AB=a \\ FE=l \\ CF=x \\ FB=a-x \end{array}\right\}$$

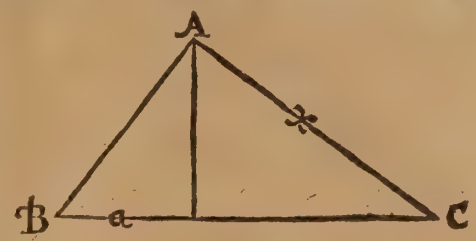
Becauſe of the Similar Triangles we find $\frac{la-lx}{x}=AF=EG$: Alſo this Equation $aa+ll=BGq$. Whence again $a+\sqrt{aa+ll}, \frac{la-lx}{x} :: l. \ x$, or $xa+x\sqrt{aa+ll}=\frac{lla-llx}{x}$, or $xxa+xx\sqrt{aa+ll}=lla-llx$, or $\left.\begin{array}{l}\sqrt{aa+ll}\\+a\end{array}\right\}xx+llx,=lla$, or $xx+\frac{llx}{\sqrt{aa+ll}+a}=lla$, which ariſes only to a Quadratic, and may be ſolv'd after the uſual Method.

*Q.* 3. There is given the Sides of a *Trapezium* ABCD, inſcrib'd in a Circle; the *Area* thereof is demanded? Which will ariſe to a much eaſier *Theorem* than that of a *Trapezium*, which can't be inſcrib'd in a Circle.

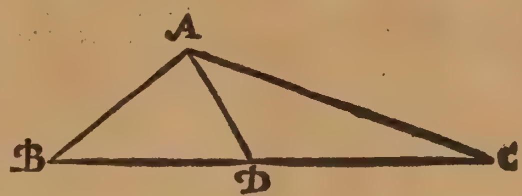



*Q.* 4.

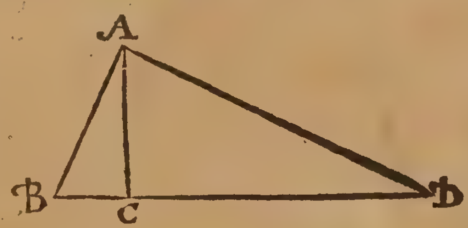
*Q.* 4. In a Right-angled Triangle ABC, $a$ the leſſer Segment of the Baſe is only given; yet with this limitation, that the unknown Perpendicular AB, ſhall be equal to the other Segment of the Baſe; the ſide AC is demanded?




*Q.* 5. In any Triangle ABC, the Angle BAD, with its oppoſite ſide BD; and the Angle DAC, with its oppoſite ſide DC are given, to find all the Sides?

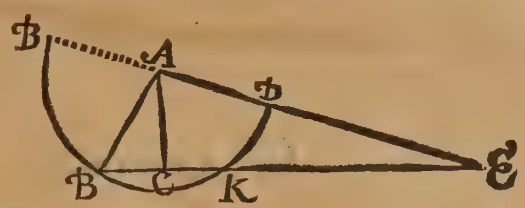



*Q.* 6. In any Right-angled Triangle ABD, if a Perpendicular AC be let fall from the right Angle upon the oppoſite Side, thereby dividing the whole into two Triangles ſimilar, and like the whole; at the ſame time, conſtituting five Parts, any two of them are given, to find the other three?




*Q.* 7. In the ſame Triangle $AB+BD=p$, and $AC+DC=q$ are given, the Parts are demanded?

*Q.* 8. In any Right-angled Triangle ABE, the Difference of the Segments of the *Hypothenuſe* KE, with either of the Sides BA or AE, are given, to find all the other Parts?




In the ſame Triangle the Difference of the Legs BA and AE, *viz.* DE is given, and the Perpendicular let fall on the *Hypothenuſe*, *viz.* AC; to find the *Hypothenuſe*, and all the other Parts?

To give *Analitic Theorems* for the inſcribing a three, four, five, ſix, ſeven, eight, nine, ten, eleven, and twelve-ſided Figure in a Circle.

*For Equations in Cubics and higher Powers.*

To give *Analitic Theorems* for the *Triſection*, *Quadriſection*, *Quinquiſection*, *Sextiſection*, &c. of an Arch or Angle.

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## *Geometric Effections or Conſtructions in ſimple Equations.*

I Suppoſe all Simple Equations are reducible to this Form, $z=\frac{ab}{c}$. Then for the Conſtruction $zc=ab$; which reſolv'd into Proportionals, gives $c.a::b.z:$ So that to find the Value of $z$, is only to find a fourth Proportional.

§. 1. The Number of Dimenſions in the Numerator, always exceeds that of the Denominator by one, becauſe of Diviſion, (for a Line is Heterogeneous to a Square Cube, *&c.*); And if it be not ſo at firſt, let $d$ (or any other Letter be put for *Unity*); and let that (or the Powers thereof, if need be) ſupply what's wanting on either Side, without altering the Value thereof.

For Inſtance, If $z=\frac{bcl}{e}$, then $z=\frac{bcl}{ed}$; if $z=\frac{mnros}{gg}$, then $z=\frac{mnros}{ggdd}$; if $z=\frac{lm}{gggr}$, then $z=\frac{lmddd}{gggr}$.

§. 2. Let this Equation be propos'd, $z=\frac{abc}{de}$, take any Quantity, ſuppoſe $m$ in the place of $\frac{ab}{d}$, then is $z=\frac{mc}{e}$, which is the *firſt Form.* Again, let $z=\frac{abcd}{efg}$, take $m=\frac{ab}{e}$ and $n=\frac{cd}{f}$, then is $z=\frac{mn}{g}$ of the *firſt Form*, 'tis the ſame if a Simple Equation was ſtill more involved. Suppoſe $z=\frac{abcdefg}{bklmno}$. take $\frac{ab}{b}=p$, $\frac{cd}{k}=q$, $\frac{ef}{l}=r$; then is $\frac{pqrg}{mno}=z$. Again, $\frac{pq}{m}=s$, $\frac{rg}{n}=t$; whence $\frac{st}{o}=z$.

§. 3. Let this Equation be propos'd, $z=\frac{ab+ac}{b}$, take $m=b+c$, then is $z=\frac{am}{b}$. Again, $z=\frac{ab+cd}{e}$, ſince any Rectangle may be chang'd into another of the ſame Value, one of the Sides being given; inſtead of $ab$ take a Rectangle, whoſe one Side ſhall be either $c$ or $d$; thus $c\,.\,a::b\,.\,y$, then $ab=cy$, and $y=\frac{ab}{c}$, whence we have this new Equation $z=\frac{cy+cd}{e}$; then again taking $y+d=m$, $z=\frac{cm}{e}$ of the *firſt Form.* If there are many Members of the Numerator, reduce them one by one; if they be of ſeveral Dimenſions, make them of the ſame by the Multiplication of *Unity* $(d)$ or its Powers into them: If they have different Denominators, reduce them to one, and then work as before; in all which Reductions $x$, the Number ſought, will be a fourth Proportional here.

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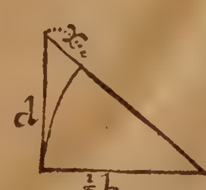
## *Of Quadratic Constructions.*

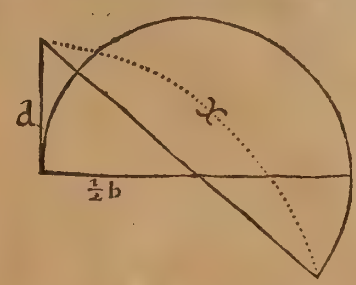
ALL Quadraticks will fall under ſome one of theſe four Forms, or what is very readily deducible from them. (1.) $xx=dd$. (2.) $xx+bx=dd$. (3.) $xx-bx=dd$. (4.) $xx-bx=-dd$.

And when reduc'd, (1.) $x=\sqrt{dd}=d$. (2.) $x=\sqrt{dd+\frac{bb}{4}}-\frac{b}{2}$. (3.) $x=\sqrt{dd+\frac{bb}{4}}+\frac{b}{2}$. (4.) $x=\sqrt{\frac{bb}{4}-dd}+\frac{b}{2}$.

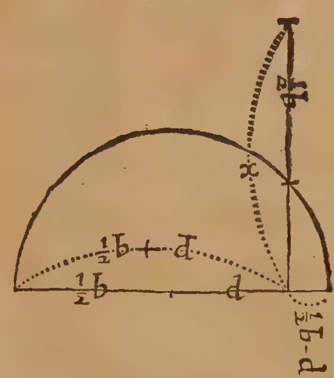
§. 1. If the firſt, there's no need of any conſtruction for $x=d$; if $xx=bd$, here it's evident that $x$ is a mean Proportional betwixt $b$ and $d$; for $b\,.\,x::x\,.\,d$: Whence $bd=xx$ as before. Deſcribe a Circle, whoſe Diameter let be $b+d$ as one Line, and at their point of meeting erect a Perpendicular $x$ ſought, which is a mean proportional betwixt $b$ and $d$, (by 13. e 6.)


§. 2. Let the ſecond Caſe be propos'd, $x=\sqrt{dd+\frac{bb}{4}}-\frac{b}{2}$ at right Angles erect $d$, and $\frac{1}{2}b$; the Squares of which (by 47. e. 1.) are equal to that of the *Hypothenuſe* $=dd+\frac{bb}{4}$, the Root of which leſſen'd by $\frac{1}{2}b$, gives $x$ ſought.






The third Case is $x = \sqrt{dd+\frac{bb}{4}}+\frac{b}{2}$, which differs not from the last, save only that $\frac{1}{2}b$ is not taken out of the *Hypothenuse*, but added thereto to make up the Value of $x$ sought.




The fourth and last Case is, $x=\sqrt{\frac{bb}{4}-dd}+\frac{b}{2}$, $\frac{bb}{4}-dd$, is a Rectangle made by the Multiplication of $\overline{\frac{1}{2}b+d}\times\overline{\frac{1}{2}b-d}$, describe a Circle whose Radius shall be $\frac{1}{2}b$; to which add $d$ in the same Line, and from $\frac{1}{2}b$ subduct $d$ as in the Figure, then is the Perpendicular which stands on the meeting of $\frac{1}{2}b+d$, and $\frac{1}{2}b-d$, a mean Proportional betwixt them and the Square thereof, is equal to their Rectangle; to the Root of which (that is the Perpendicular it self) if $\frac{1}{2}b$ be added in one Line, it gives the Value of $x$ sought.

All adfected Quadratics are reducible to one of the three last Forms, I shall give one perplex'd Instance for all; $xx+x=dd-aa-\frac{ddcc}{bb-aa}$, take $dm=aa$; then instead of $dd-aa$, we have $dd-dm$; take $k$ for $d-m$, then is $dk=dd-aa$. Again, let $aa=br$, then $bb-aa=bb-br$; take $p=b-r$, and we have $bp=bb-aa$, then also is $dd-aa-\frac{ddcc}{bb-aa}=dk-\frac{ddcc}{bp}$.

Yet again, take $n=\frac{dd}{b}$ and $o=\frac{cc}{p}$, then is $dk-no=dk-\frac{ddcc}{bp}$.

Again, take $no=dg$, then is $dk-no=dk-dg$; and if $b$ be assum'd for $k-g$, $dk-dg=db$.

Lastly, Take a mean proportional betwixt $d$ and $b$: Suppose $l$, then $db=ll$, then will $dd-aa-\frac{ddcc}{bb-aa}=ll$, then also is $xx+x=ll$, which was to be done.

Those that would see more of the Practice of Geometrical Constructions, may consult *Oughtred*'s *Clavis*, and *De Cartes* Geometry.

As for the Construction of Cubic, Biquadratic, and higher Equations, 'tis necessary first to understand *Conic Sections*, therefore I omit that as foreign to my Purpose at present.

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## *Of Cubic, Biquadratic, and higher Equations.*

THE Origination of a Cubic Equation, is the same with that of an adfected Quadratic. *Ex. Gr.*

1. Put $x=a$, $x=b$, $x=c$. Then is

$$\begin{array}{r} x-a=0 \\ x-b=0 \\ x-c=0 \\ \hline xxx-axx+abx \\ -bxx+acx \\ -cxx+bcx-bcd=0. \end{array}$$

2. Put $x=a$, $x=b$, $x=-c$. Then is

$$\begin{array}{r} x-a=0 \\ x-b=0 \\ x+c=0 \\ \hline xxx-axx+abx \\ -bxx-acx \\ +cxx-bcx+bcd=0. \end{array}$$

3. Put $x=-a$, $x=-b$, $x=+c$. Then is

$$\begin{array}{r} x+a=0 \\ x+b=0 \\ x-c=0 \\ \hline xxx+axx+abx \\ +bxx-acx \\ -cxx-bcx-bcd=0. \end{array}$$

I omit the last Case, where, $a, b, c,$ are all Negative, which is impracticable.

1. After the same manner any Biquadratic, Cubiquadratic, or higher Equation may be deriv'd, where there will be always so many Values of the unknown Quantity, as is the *Index* of the *highest Power*, sometimes Positive, sometimes Negative, sometimes Imaginary, and sometimes Mix'd.

2. The *Coefficient* of the second Term, is the Sum of all the Roots under contrary Signs.

3. The *Coefficient* of the third Term, is the Rectangles of all the Roots so many ways as they can be taken, *viz.* three in a Cube, four in Biquadrate, *&c.* The Coefficient of the fourth Term, if we proceed to Biquadrates, Cubiquadrates, *&c.* is the Sum of all the Solids of the Roots, so many ways as they can be taken. The Coefficient of the fifth Term will be the Sum of all the Sursolids of the Roots, so many ways as they can be taken; and so on *ad infinitum*. Lastly, The Absolute known Number in the Square, is the Rectangle of the two Roots; in the Cube, the Solid of the three Roots; in the Biquadrate, the Sur-solid of the four Roots, *&c.*

4. When the Coefficients are mix'd, if the Sum of the Negative Roots taken together, is equal to the Sum of the Positive, the second Term is destroy'd in that Equation: Also if the Rectangles of the Negative Roots are equal to the Rectangles of the Positive, the third Term will be destroy'd; and so on.

As for the Determination of the Quality of Roots in a Cubic Equation, and higher if need be, *viz.* how many *Positive*, and how many *Negative*, &c. I think we need not follow Mr. *Harriot*'s Method, which is very much perplex'd in the deriving variety of Cases, as by his *Reciprocals*, his *parting a Simple Quantity* into the *Form* of a Binomial, *&c.* All the sixteen Cases in Cubics (for so many I find) are very easily and naturally derived, only from the different Combinations of the Values of the Coefficients in the three preceding Originations.

I shall give one Example of my Method, by which all the rest will be evident: Let the second Case be reassum'd where the *Genesis* arises, from two Positive Roots and one Negative.

From the different Combinations of the Coefficients in this Example, there will arise three of the sixteen Cases in Cubics before the second or third Term be taken away.

$$\begin{array}{lr} x=a & x-a=0 \\ x=b & x-b=0 \\ x=-c & x+c=0 \\ \hline & xxx-axx+abx \\ & -bxx-acx \\ & +cxx-bcx-abc=0. \end{array}$$

Let $a+b$ taken together be either greater or lesser than $c$,

(for

( for ſhould they be equal, the 2*d* Term would be deſtroy'd) then by expreſſing the Coefficient of the ſecond Term in one Letter: Suppoſe $p$, there can be only two Alternations according as the two Poſitive Roots, or the one Negative prevails, *viz.* $-p$, or $+p$.

For the Coefficients of the third Term: Suppoſe $c$ either greater, equal, or leſſer than $a+b$. Firſt, If $c$ be greater than $a+b$, $ac$ and $bc$ together will be greater than $ab$, becauſe $bc$ by it ſelf is greater than $ab$. (2.) If $c$ be equal to $a+b$, $ac+bc$ will be greater than $ab$, becauſe $ac$ it ſelf is greater than $ab$, which two are but one Caſe. Again, ſuppoſing $c$ leſſer than $a+b$, the Defect will be either great or little. If $c$ be moderately leſs than $a+b$, then $ca+cb$ may be taken greater than $ab$, which is a ſecond Alternation. Laſtly, If $c$ be taken very little, $ca+cb$ may be leſſer than $ab$; which is the third Alternation, and all that can be made in the Coefficients of the third Term.

Add theſe three Alternations to the two firſt made by the Coefficients of the ſecond Term, and let $q$ ſtand for the Total of the laſt Coefficients, and they will ariſe thus.

$\left.\begin{matrix} xxx - pxx \\ xxx + pxx \end{matrix}\right\}$ For the firſt Alternation.

For the Second, $xxx - pxx \left\}\begin{matrix} -qx \\ +qx \end{matrix}\right. - abc = 0.$

For the Third, $xxx + pxx \; \} -qx - abc = 0.$

From ſuch different Alternations, and Values of all the Coefficients of every Term in any Equation, there's a Neceſſity that ſo often as $+$ follows $+$, or $-$ follows $-$, (all the Terms being put over to one Side) ſo many are the Negative Roots; and ſo often as $+$ follows $-$, or the contrary, ſo many are the Poſitive Roots in any Equations, (I mean of real Ones).

Upon theſe Conſiderations I determine the Qualities of the Roots of all the Caſes in the three preceding *Geneſes*, as follows.

| | | |
|---|---|---|
| 1. Caſe, | 1. $xxx - pxx + qx = +r$ | All the Roots are Poſitive. |
| 2. Caſe, | 2. $xxx - pxx - qx = -r$ | The two Poſitives prevail, and the Negative is moderately big. |
| | 3. $xxx - pxx + q = -r$ | The two Poſitives prevail, and the Negative is very ſmall. |
| | 4. $xxx + pxx - qx = -r$ | The Negative is greater than the two Poſitives. |
| 3. Caſe, | 5. $xxx + pxx - qx = +r$ | The two Negatives prevail, and the Poſitive is moderate. |
| | 6. $xxx + pxx + qx = +r$ | The two Negatives prevail, and the Poſitive is very ſmall. |
| | 7. $xxx - pxx - qx = +r$ | The Poſitive is greater than the two Negatives. |
| 2. Caſe, | 8. $xxx - pxx * = -r$ | Two Poſitives greater than one Negative. |
| | 9. $xxx + pxx * = -r$ | One Negative Root and two Imaginary. |
| 3. Caſe, | 10. $xxx + pxx * = +r$ | Two Negatives greater than one Poſitive. |
| | 11. $xxx - pxx * = +r$ | One Poſitive Root and two Imaginary. |
| 2. Caſe, | 12. $xxx * + qx = -r$ | One Negative Root and two Imaginary. |
| | 13. $xxx * - qx = -r$ | Two Poſitives equal to one Negative. |
| 3. Caſe, | 14. $xxx * - qx = +r$ | Two Negatives equal to one Poſitive. |
| | 15. $xxx * + qx = +r$ | One Poſitive Root and two Imaginary. |
| 1, 2, or 3*d* Caſe, | 16. $xxx * * = +r$ | One Poſitive Root and two Imaginary. |

☞ *Note*, That if in the 13*th* or 14*th* Forms, if $\frac{1}{27}p^3$ be greater than $\frac{1}{4}qq$, the two Positive Roots in the first, and the two Negative Roots in the last will be Imaginary.

From the three preceding Cases only, may also be deriv'd the 46 different Combinations in Biquadratics, and also of yet higher Equations, but this would be a Business of greater Labour than Use, and therefore I omit it.

I shall also pass over the Method of resolving these Cubics as deliver'd by *Cardan*, because his Rules reach not all Cases as where the Root is under Unity: Or upon supposition they did, what a tedious Operation (after that of taking away the second Term) would it amount to, especially if the Root sought were irrational? We must extract two Squares and two Cubes, before we can arrive to what we want. But for such as are in love with this Method, I shall barely set down the *Theorems* for them as follows, reserving a full Resolution of them, (and higher Equations) till we come to the easier Methods of *infinite Approximations.*

$x^3 * + qx = + r.$ Root. $x = \sqrt{(3)}\,\overline{\tfrac{1}{2}r + \sqrt{\tfrac{1}{4}rr + \tfrac{1}{27}q^3}} - \sqrt{(3)}\,\overline{-\tfrac{1}{2}r + \sqrt{\tfrac{1}{4}rr + \tfrac{1}{27}q^3}}$

$x^3 * - qx = + r.$ Root. $x = \sqrt{(3)}\,\overline{\tfrac{1}{2}r + \sqrt{\tfrac{1}{4}rr - \tfrac{1}{27}q^3}} + \sqrt{(3)}\,\overline{+\tfrac{1}{2}r - \sqrt{\tfrac{1}{4}rr - \tfrac{1}{27}q^3}}$

$x^3 * - qx = - r.$ Root. $x = -\sqrt{(3)}\,\overline{\tfrac{1}{2}r + \sqrt{\tfrac{1}{4}rr - \tfrac{1}{27}q^3}} - \sqrt{(3)}\,\overline{+\tfrac{1}{2}r - \sqrt{\tfrac{1}{4}rr - \tfrac{1}{27}q^3}}$

$x^3 * + qx = - r.$ Root. $x = -\sqrt{(3)}\,\overline{\tfrac{1}{2}r + \sqrt{\tfrac{1}{4}rr + \tfrac{1}{27}q^3}} + \sqrt{(3)}\,\overline{-\tfrac{1}{2}r + \sqrt{\tfrac{1}{4}rr + \tfrac{1}{27}q^3}}$

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## *Of dissolving Compound Equations.*

FROM the Origination of Compound Equations, we have a Method of dissolving them again, (if by any means we can discover any of the Roots) *viz.* by depressing a Biquadratic to a Cubic, a Cubic to a Quadratic, a Quadratic to a Lateral. For Instance, Let the following Quadratic $xx - 5x = 6$, be generated from the Roots 2 and 3.

$$
\begin{array}{ll}
x = 2 & x - 2 = 0 \\
x = 3 & x - 3 = 0 \\
\hline
 & xx - 2x \\
 & \quad -3x - 6 \\
\end{array}
$$

$$
x - 2 = 0 \,\big)\; xx - 5x - 6 = 0 \;\big(\, x - 3 = 0
$$

$$
\begin{array}{l}
xx - 2x \\
\hline
-3x - 6 \\
-3x - 6 \\
\hline
\cdot
\end{array}
$$

Suppose I had by some means discovered that one of the Roots or Values of $x$ was 2, then the other would be found by Division, as in the Operation. Imagine the same in Equations more Compound.

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## *To find all the Roots of a Cubic Equation.*

SUppose in a Cubic Equation, whose second Term is taken away, I have occasion for all the Roots; put $2x$ for the Sum of the two, whether Positive or Negative, $2y$ their Difference; $2x$ will also be the third, whether Negative or Positive, because it must be equal to the other two, or the second Term could not be destroy'd; then is $x + y$ the greater Root of the two, $x - y$ the Less. Let the three Roots be multiply'd with their own Signs, so many ways as they can be taken to form a Coefficient equal to that of the third Term, and there arises $-3xx - yy$.

Let

Let any Equation be propos'd $\left\{\begin{array}{l} zzz - pz = -q \\ zzz - pz = +q \end{array}\right\}$ Then from the Combinations of the Coefficients of the third Term, we have this Equation, $-3xx - yy = -p$, or $3xx + yy = p$, or $p - 3xx = yy$, or $y = \sqrt{p - 3xx} = \frac{1}{2}$ the Difference of the two Roots. So that having the greateſt, whether Negative or Poſitive, given or found firſt; and by conſequence the Sum, or half the Sum of the other two, all the three are given at once by the preceding Theorem; only we are to remember, that $2x$ is equal to $z$, and by equivalent Subſtitution $y = \sqrt{p - \frac{3}{4}zz}$. *Ex.* $zzz - pz = -6$, or $zzz - 7z = 6$. Let the greateſt Negative $z$ ($=$ to the other two Poſitive) be given or found, *viz.* Suppoſe 3; then is $\frac{1}{2}z + \sqrt{p - \frac{3}{4}zz}$, the greater $\left\{\begin{array}{l} \text{Poſitive,} \\ \text{Negative,} \end{array}\right.$ and $\frac{1}{2}z - \sqrt{p - \frac{3}{4}zz}$, the leſſer $\left\{\begin{array}{l} \text{Poſitive,} \\ \text{Negative,} \end{array}\right.$ *viz.* $\frac{1}{2}3 + \sqrt{7 - \frac{3}{4}9} = 1.5 + .5 = 2$ the greater $\left\{\begin{array}{l} \text{Poſitive,} \\ \text{Negative.} \end{array}\right.$ and $1.5 - .5 = 1$ the leſſer $\left\{\begin{array}{l} \text{Poſitive,} \\ \text{Negative.} \end{array}\right\}$ And hence alſo we have another Determination of Imaginary Roots, *viz.* when theſe Theorems, or one of them, infer an Impoſſibility.

But if no Term be wanting, as in this Equation, $zzz - pzz - qzz = -r$, where there are two Poſitive Roots, and one Negative moderately big; let $2x$ be the Sum of the Poſitive, $2y$ their Difference; then is $x + y$ the greater Poſitive, $x - y$ the Leſſer, and $2x - p$ the third Negative; as is evident from the Nature of the Coefficients in the ſecond Term; whence $2x - p = z$, or $\frac{z+p}{2} = x$.

Let the Roots, with their proper Signs, be multiply'd, ſo many ways as they can be taken, and their Difference equated to the Coefficient of the third Term, *viz.* $-q$, and then there will ariſe $-3xx - yy + 2px = -q$, or $2px + q - 3xx = yy$, or $y = \sqrt{2px + q - 3xx}$; but $x$ was found before equal to $\frac{z+p}{2}$, $z$ being the Negative Root; which ſubſtituted eqivalently, gives $y = \frac{1}{4}\sqrt{pp + 4q - 3zz - 2pz}$: Whence as before, $\frac{\frac{1}{4}\sqrt{pp + 4q - 3zz - 2pz} + z + p}{2}$ equal to the greater Poſitive, and $\frac{\frac{1}{4}\sqrt{pp + 4q - 3zz - 2pz} - z - p}{2}$, equal to the leſſer Poſitive: But this ſuppoſes $z$ the Negative or ſingle Root firſt found. The like will ſerve for all the reſt of the Caſes, relation being had to the Signs of the Roots in forming the Theorem, the ſingle Root being firſt found out, and the Sum and Difference of the other two, whether Poſitive or Negative, being call'd $2x$, $2y$; but if all the Roots be Poſitive, let $2x$ be the Sum of the leſſer, $2y$ their Difference, and let the greateſt be $2x \pm p$. Hence alſo in Cubic Equations having all the Terms, we have a Method for determining imaginary Roots, *viz.* when the preceding Theorems, or one of them infer an Impoſſibility.

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## *Of Increaſing and Decreaſing the Value of an unknown Equation without deſtroying it.*

SUppoſe I would double this Quadratic $xx + bx = d$; Multiply each Term by a Series of Proportionals, beginning with *Unity*, whoſe ſecond Term is 2. Thus $1 \times xx + 2 \times bx = 4 \times d$, which deſtroys the Equation; reſtore it again by a backward Multiplication of the ſame Proportionals $4 \times 1 \times xx + 2 \times 2 \times bx = 1 \times 4 \times d$; Inſtead of $x$ take another unknown Quantity, $y$, ſuppoſed equal to $2x$, then is $xx = \frac{1}{4}yy$: And there reſults another Equation, which compar'd with the firſt, ſatisfies the Demand, *viz.* $\left.\begin{array}{l} 4 \times 1 \times xx + 2 \times 2 \times bx = 1 \times 4 \times d \\ yy + 2by = 4d \end{array}\right\}$

If

If I would have an Equation which shall be $\frac{1}{3}$ of this Cubic $xxx + bxx + cx = d$, multiply by a Series of Proportionals, beginning with 1, whose second Term is $\frac{1}{3}$, and put $y$ for $\frac{1}{3}x$, then by the preceding Method we shall have this new Equation, $yyy + \frac{1}{3}byy + \frac{1}{9}cy = \frac{1}{27}d$. Or more generally thus, put $a$ for any Number, Integer, or Fraction, and reassume the preceding Equation, $\left\{\begin{matrix} xxx + bxx + cx = d, \\ yyy + abyy + aacy = aaad, \end{matrix}\right.$ then is where the Value of $y$ to $x$, is as $a$ to 1.

The Uses of this Artifice are very great; some of which are these.

Use 1. *To free an Equation from Fractions.* Suppose $xx + \frac{1}{3}bx = d$, putting $y = 3x$, we have $yy + by = 9d$. Again, suppose this Equation was propos'd, $xxx + \frac{b}{a}xx = d$; that is, $xxx + \frac{b}{a}xx + ox = d$, putting $y = ax$, we have $yyy + byy * = aaad$.

Use 2. *To take away the second Term in any Equation.* Suppose $xx + bx = d$, put $y - \frac{1}{2}b = x$.

Then is $yy - by + \frac{1}{4}bb = xx$
and $\quad\; + by - \frac{1}{2}bb = bx$ $\Big\} = d.$

$yy \quad - \quad \frac{1}{4}bb = d.$

By the same Method the second Term in a Cubic may be destroy'd; only remember that $y \pm \frac{1}{2}$ the Coefficient in the Square, $y \pm \frac{1}{3}$ the Coefficient in the Cube $y \pm \frac{1}{4}$, the Coefficient in the Biquadrate, &c. must be taken with the contrary Sign to the second Term; for if the same Sign be taken, the second Term will doubled not taken away.

Use 3. *To take away all the Coefficients in a Cubic Equation.* Which I think has not yet been done by any one; and perhaps others may make better use of it than I can at present. Suppose the second Term in a Cubic Equation taken away, or else that this is given $xxx + bx = d$, assume $y = x\sqrt{\frac{1}{b}}$, ($\sqrt{\frac{1}{b}}$, being a mean Proportional betwixt $\frac{1}{b}$ and Unity); Then multiply by a term of continual Proportionals in that Series as before; and instead of $xxx + bx = d$, we have $1 \times xxx + \sqrt{\frac{1}{b}}\,o + \frac{b}{b}x = \frac{d}{b}\sqrt{\frac{1}{b}}$ that is by equivalent Substitution $yyy + y = \frac{d}{b}\sqrt{\frac{1}{b}}$.

In all the preceding Cases, as soon as the Value of $y$ is found, the Value of $x$ is also discover'd, $y$ being always taken in some certain Proportion to $x$.

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## *Of the Punctation of Adfected Equations.*

LET a Biquadrate be made from the Binomial $x + a = p$, according to the former *Genesis of Powers*, and it will arise to this,

$xxxx + 4bxxx + 6bbxx + 4bbbx + bbbb = pppp$. Again, let a Biquadratic be found from several different Values of $x$, thus;

$$\left\{\begin{matrix} x - b = o \\ x - c = o \\ x - d = o \\ x - f = o \end{matrix}\right\} \text{And we have this } \textit{Genesis.} \left\{\begin{matrix} xxxx - bxxx + bcxx & & \\ \quad - cxxx + bdxx & & \\ \quad - dxxx + cdxx - bcdx & & \\ \quad - fxxx + bfxx - bcfx & & \\ \qquad\quad + cfxx - bdfx & & \\ \qquad\quad + dfxx - cdfx + bcdf = o. & & \end{matrix}\right.$$

Now confounding the *Homogeneal Coefficients*, and putting them all into one, we may represent their Totals thus —— $\Big\}$ $x^4 - mx + nnx - pppx = -qqqq.$

In this and the preceding *Genesis*, (from one Value of $x$, omitting the diſtinction of the *Unciæ*) 'tis evident that the Coefficients encreaſe in their Power, as the higheſt unknown Term decreaſes, and that the *laſt abſolute known Quantity* is of the ſame Power as the Firſt. Imagine the ſame under different Signs; alſo if one or more of the Terms be intercepted or loſt, the remaining will yet keep their Places. Hence in *Numeral Equations*, ſuppoſe $xxxx + 3x^3 + 16xx + 125x = 1000$, the Coefficients are firſt Lateral, then Quadratic, then Cubic, *&c.* and 'tis no matter whether they are figurate Numbers or not, *viz.* exact Squares, Cubes, *&c.* they are always ſuppoſed of that Nature. Hence we have theſe two Conſectaries.

1. *If the Root of the Coefficient (in any Place) be continually multiply'd to its degree of Adfection, and then by it ſelf again, the laſt Product ſhall be of the ſame Power with the higheſt unknown Term in the Equation.*

For Inſtance, $x^4 - mx^3 + n^2x^2 - p^3x = -qqqq$, the Coefficient $m$ is a Lateral, (therefore it ſelf a Root); and if Cub'd, (for ſo is the higheſt Power which it is join'd to, or its degree of Adfection) it becomes $mmm$; which multiplied again by it ſelf, becomes $m^4$ of the 4*th* Power, as is $xxxx$. Again, in $nnx^2$, the Root of $nn$ is $n$, its degree of Affection is a Square $nn$, which multiply'd into it ſelf, *viz.* $nn$, becomes $nnnn$ a Biquadrate. Laſtly, $p^3x$ the Root of $p$ Cube, is $p$, its degree of Affection, is only Lateral: Therefore $p$ (the Side) $\times$ $ppp$ (the Coefficient it ſelf) produces $p^4$.

2. *If the abſolute known Power be divided by any one of the Coefficients, the Quote will be of the ſame degree of Adfection with the place of ſuch Coefficient,* viz. *Lateral, if the Adfection be Lateral; Quadratic, if the Adfection be Quadratic,* &c.

For Inſtance, $x^4 + 3xxx + 16xx + 125x = 1000$: if 1000 be divided by 3, the Quote is Cubic; if by 16, the Quote is Quadratic; if by 125, 'tis Lateral. From hence then, and the preceding *Genesis*, we have a Method of Pointing any adfected Equation in order to its Extraction.

It's evident from the *Formation of Powers*, that a Square muſt be pointed every ſecond Figure, (beginning from the Right) a Cube every third, a Biquadrate every fourth; and ſo on. For ſuppoſe 57209 was given to be ſquar'd, 5 has four places after it; therefore its Square 25 will have eight Ciphers; or if Cub'd, 'tis 125 with twelve Ciphers annex'd; and ſo on, every Cipher or Place following a Figure in the Root, making 2 in the Square, 3 in the Cube, *&c.*

Let any Equation be propos'd, (in order to its pointing). Suppoſe without any Coefficient $xxx - xx = 186494880$. From the preceding *Genesis* 186494880 is Cubic, becauſe ſo is the higheſt unknown Term, therefore let it be pointed at every third Figure thus, 186494880. But ſince it alſo contains in it the Negation of $xx$, therefore imagine it alſo pointed as a Square, thus, 186494880, but with the ſame Number of Points, becauſe $xxx$ is no oftner contain'd in 186494880, than $xx$ is ſuppoſed to be taken out of it.

There are three Caſes that can only happen in pointing.

1. Where the number of Figures in the Coefficients are regular, and will admit of an equal Number of Points according to their reſpective Powers. For Inſtance, $xxxx + 13xxx + 237xx + 5927x = 100000$, where each place has two Points, determining the Value of $x$ to conſiſt of two Integers; ſo that we have for the firſt pointing this Equation $x^4 + 1x^3 + 2xx + 5x = 10$ near; whereby the Value of $x$ in its firſt Figure is readily diſcover'd. 'Tis the ſame if interrupted, *viz.* $xxxx + 9532x = 123579$, then $x^4 + 9532x = 12$; or if the natural Order of Places be inverted, *viz.* $x^4 + 3537xx \; 35xxx = 2598372$, where $x^4 + 35xx - 3x^3 = 259$.

2. The ſecond Caſe is call'd a *Devolution*, where the Number of Figures is too ſhort in ſome of the Coefficients: And here it's eaſier than before to find the Value of $x$ as to the firſt Figure, for we have no more to do than prefix ſo many Ciphers in each, as are the number of Figures that are wanting.

N For

For Inſtance, $xxx + 24x = 587914372$; that is, $xxx + \dot{0}0\dot{0}24x = 5\dot{8}79\dot{1}43\dot{7}2$. Whence $xxx + 0x = 587$, or $xxx = 587$.

3. The third, which is called a *Caſe of Anticipation*, where ſome of the Coefficients run beyond their juſt Number of Punctations, and this is much more troubleſome than either of the former.

For Inſtance, $xxx + 4xx + 376958x = 753922$; which pointed as before, would be $xxx + \dot{0}4xx + 3\dot{7}69\dot{5}8x = 7\dot{5}39\dot{2}2$; or $x^3 + 3769x = 753$, where $x = .1$, whereas 'tis equal to 2 preciſely. The beſt Expedient I can meet with in this, (if the Figures have but one Punctation) is that of Dr. *Wallis*, who ſuppoſes the firſt Figure ariſing to be 1, 10, 100, 1000, *&c.* Or downwards, .1. .01 .001, *&c.* And then having found by trial whether it lies betwixt 1 and 10, or 10 and 100, *&c.* He takes the Medium 5, 50, *&c.* till he meets with it. But this Expedient will alſo prove fruitleſs for the ſecond Figure, if the *Anticipation* be large: we have therefore but one way left us that I know of, and that is the incomparable Method of a *Converging Series*, lately diſcover'd by the ingenious Mr. *Raphſon*; which though it might be help'd by Punctation, as in the two preceding Caſes, yet it has no abſolute Neceſſity of it, for by aſſuming any Number at pleaſure, no matter how far off the Truth, (as to the poſſibility of its accompliſhing the End) it will converge to it infinitely quicker than by any Eſſays or Trials whatever in the moſt perplex'd *Anticipations*, therefore extreamly ready and eaſy in the other Caſes. The further Uſes of it are beſt explain'd by Examples; however I thought it neceſſary to ſay ſomething of Punctations here, having occaſion to uſe them hereafter, becauſe Mr. *Raphſon* has not done it in his *excellent Series*, but only refer'd to *Vieta*, *Oughtred*, &c. which perhaps every one has not at hand, or can't read them in Latin. But Mr. *Raphſon*'s Buſineſs was not Repetition, or a troubling himſelf with what was requiſite to be known before he could be underſtood, preſuming reaſonably enough, that his Reader was not ignorant of what Advancements had been made before him in the *Exegiſis Numeroſa* of the aforementioned Authors.

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# *Of* Infinite Approximations, *or a Numeral* Converging Series *for all Adfected Equations whatever.*

*Example* 1.

LET any Equation be propos'd, ſuppoſe $xx = a$.

1. Put $p$ (a known Quantity) $+ y$ (an unknown Quantity) equal to $x$. Then is $\overline{p+y}|^2$, or $pp + 2py + yy = (xx =) a$.

2. By Tranſpoſition $2py = a - pp - yy$, or $y = \frac{a-pp-yy}{2p}$; or which is the ſame thing, $y = \frac{a-pp}{2p} - \frac{yy}{2p}$. But $x = p + y$ by Poſition. *Ergo*, $x = p + \frac{a-pp}{2p} - \frac{yy}{2p}$, in which Equation $p + \frac{a-pp}{2p}$ is wholly a known Quantity, and $- \frac{yy}{2p}$ an unknown.

3. Put $q = p + \frac{a-pp}{2p}$, and $-z = -\frac{yy}{2p}$, then is $x = q - z$. Then alſo is $qq - 2qz + zz = (xx =) a$; and by Tranſpoſition and Diviſion as before $z = \frac{qq-a}{2q} + \frac{zz}{2q}$. But $x = q - z$ by Poſition; *Ergo*, $x = q + \frac{a-qq}{2q} - \frac{zz}{2q}$ where the known $q + \frac{a-qq}{2q}$, is evidently leſs than the former known Quantity $q$, becauſe $qq \sqsubset a$.

4. Put

4. Put $r = q + \frac{a-qq}{2q}$, and $-v = -\frac{zz}{2q}$; and by the same Method of procedure we shall have $x = r + \frac{a-rr}{2r} - \frac{vv}{2r}$ the known Quantities which are too great being still decreas'd.

5. Put $s = r + \frac{a-rr}{2r}$ and $-\omega = -\frac{ss}{2r}$, and by a like repeated Process there will arise $x = s + \frac{a-ss}{2s} - \frac{\omega\omega}{2s}$; which last $-\frac{\omega\omega}{2s}$ will be so very small, that we need make no subduction for it, if the Value of $a$ be not above 32 Figures, which I think is sufficient for Practice.

Hence then by collecting the whole together we have this Series;
$p + \frac{a-pp}{2p}$ $(=q)$ $q + \frac{a-qq}{2q}$ $(=r)$ $r + \frac{a-rr}{2r}$ $(=s)$ $s + \frac{a-ss}{2s} = x$ *proxime*; or according to Mr. *Raphson's* Method, $p + \frac{a-pp}{2p}$ only, repeated at pleasure is equal to $x$, where the Value of $p$ always changes at every Operation; and the Value of $a$ is first 1 Punctation, then 2, then 4, then 8, then 16, and so on as far as any one pleases to prosecute it, from the same Considerations which I mention'd in the preceding Series for Extraction of Square Roots.

*Examp.* 2. Let this affected Quadratic be propos'd, $xx + bx = c$.

1. Put $x = p + y$; then is $\left.\begin{matrix} pp + 2py + yy \\ bp + by \ldots \end{matrix}\right\} \begin{matrix} =xx \\ =bx \end{matrix}\Big\} = c$. That is,

$y = \frac{c-pp-bp-yy}{2p+b}$; or which is the same thing, $y = \frac{c-pp-bp}{2p+b} - \frac{yy}{2p+b}$, but $x = p + y$; therefore $x = p + \frac{c-pp-bp}{2p+b} - \frac{yy}{2p+b}$. Now putting $q = p + \frac{c-pp-bp}{2p+b}$, and $-z = -\frac{yy}{2p+b}$. By the same Procedure repeated at pleasure, we have this Series,

$$p + \frac{c-pp-bp}{2p+b}\ (=q)\ q + \frac{c-qq-bq}{2q+b}\ (=r)\ r + \frac{c-rr-br}{2r+b}\ (=s)\ s + \frac{c-ss-bs}{2s+b} = x.$$

Or according to Mr. *Raphson's* Method, $p + \frac{c-pp-bp}{2p+b}$ only repeated as far as there is occasion, is equal to $x$, $p$ acquiring a new Value every Operation; also $b$ and $c$ changing their Value, reaching first to one Punctation, then to two, then to four, then to eight, and so on, or at least as far as there are Punctations; and when there's no more their Value is fix'd, tho $p$ will always converge and vary *ad infinitum*.

*Examp.* 3. Let this affected Cubic Equation be propos'd, $x^3 + bxx + cx = d$.

Putting $x = p + y$, we have this new Equation resulting. $\left.\begin{matrix} ppp + 3ppy + 3pyy + yyy \\ bpp + 2bpy + byy \ldots \\ cp + cy \ldots\ldots \end{matrix}\right\} \begin{matrix} =xxx \\ =bxx \\ =cx \end{matrix}\Bigg\} = d.$

Then is $\frac{d-ppp-bpp-cp}{3pp+2bp+c} - \frac{3pyy-byy-yyy}{3pp+2bp+c} = y$; But $p + y = x$. Therefore

$x = p + \frac{d-p^3-bp^2-cp}{3p^2+2bp+c} - \frac{3pyy-byy-yyy}{3pp+2bp+c}$. Now putting $q$ for all that's known, as before, and $-z$ for all that's unknown, and so repeating the same Process arbitrarily, we shall have this Series;

$$p + \frac{d-p^3-bp^2-cp}{3p^2+2bp+c}\ (=q)\ q + \frac{d-q^3-bq^2-cq}{3q^2+2bq+c}\ (=r)\ r + \frac{d-r^3-br^2-cr}{3r^2+2br+c},\ \&c. = x.$$

And so on in all higher Equations, representing always all those Quantities which are affected with the *Powers* of the unknown *assum'd Quantity* by another unknown, thereby driving forward and decreasing that unknown Value, till it becomes so small

N 2

ſmall that it may ſafely be rejected, and what is known taken for Truth it ſelf, as being indeterminately near it: remembring alſo, that all the Values of the Coefficients, as alſo the laſt *abſolute known Number* change, ſo long as the Punctations laſt; but no longer, though the Value of the aſſum'd Quantity will ever *converge* and alter.

Before I proceed to Examples, I ſhall give the *Series* for the four Caſes in Quadratics, as alſo the fourteen uſeful Caſes in Cubics, leaving others to calculate higher as they have occaſion.

*The four Quadratic Series.*

| | |
|---|---|
| 1. $xx+bx=c$ | $x=\frac{c-\overline{p-b}\times p}{2p+b}+p$ |
| 2. $xx-bx=c$ | $x=\frac{c+\overline{b-p}\times p}{2p-b}+p$ |
| 3. $-xx+bx=c$ | $x=\frac{c+\overline{p-b}\times p}{b-2p}+p$ |
| 4. $xx=c$ | $x=\frac{c-pp}{2p}+p.$ |

*The fourteen Cubic Series.*

| | |
|---|---|
| 1. $xxx=c$ | $x=\frac{b-p^3}{3p^2}+p$ |
| 2. $xxx+cx=d$ | $x=\frac{d-\overline{pp-c}\times p}{3pp+c}+p$ |
| 3. $xxx-bx=d$ | $x=\frac{d+\overline{c-pp}\times p}{3pp-c}+p$ |
| 4. $-xxx+cx=d$ | $x=\frac{d+\overline{pp-c}\times p}{c-3pp}+p$ |
| 5. $xxx+bxx=c$ | $x=\frac{c-\overline{pp-bp}\times p}{\overline{3p+2b}\times p}+p$ |
| 6. $xxx-bxx=c$ | $x=\frac{c+\overline{bp-pp}\times p}{\overline{3p-2b}\times p}+p$ |
| 7. $-xxx+bxx=c$ | $x=\frac{c+\overline{pp-bp}\times p}{\overline{2b-3p}\times p}+p$ |
| 8. $x^3+bx^2+cx=d$ | $x=\frac{d-\overline{pp-bp-c}\times p}{c+\overline{3p+2b}\times p}+p$ |
| 9. $x^3-bxx+cx=d$ | $x=\frac{d+\overline{bp-pp-c}\times p}{c+\overline{3p-2b}\times p}+p$ |
| 10. $x^3+bxx-cx=d$ | $x=\frac{d+\overline{c-pp-bp}\times p}{\overline{3p+2b}\times p-c}+p$ |
| 11. $x^3-bxx-cx=d$ | $x=\frac{d+\overline{bp-pp-c}\times p}{\overline{3p-2b}\times p-c}+p$ |
| 12. $-x^3+bxx+cx=d$ | $x=\frac{d+\overline{pp-bp-c}\times p}{c+\overline{2b-3p}\times p}+p$ |
| 13. $-x^3+bxx+cx=d$ | $x=\frac{d+\overline{pp+bp-c}\times p}{c-\overline{3p-2b}\times p}+p$ |
| 14. $-x^3+bxx-cx=d$ | $x=\frac{d+\overline{pp+c-bp}\times p}{\overline{2b-3p}\times p-c}+p$ |

No one that underſtands how to convert a Literal Theorem into a Numeral Operation, can be ignorant how to apply the preceding *Theoretic Series.* Yet notwithſtanding the Method is ſo very natural and eaſy, I ſhall give ſome Examples.

I have formerly taken notice, that in adfected Quadratics, if the *Homogeneum Comparationis* ariſes high, this *Series* is preferable to the common Way; but in all higher Equations whatever, it infinitely exceeds any *Exegiſis Numeroſa* that has yet been found out.

Let this Adfected Quadratic be propos'd, $xx+587x=987459$, and let the Value of $x$ be found to five or ſix Places in Decimals; which is the ſame thing as to find the Value of $x$ (if Rational) where the *abſolute known Quantity* ariſes to twelve Places.

Let

Let $b=587$, and $d=987459$. $\qquad xx+5\dot{8}7x=98\dot{7}45\dot{9}$

After Punctation we have first $xx+5x=98$ $\qquad xx+bx=d$

$2dly$, $xx+58x=9874$

$3dly$, $xx+587x=987459$

Also $b=5$, next $b=58$, lastly, $b=587$. Again, $d=98$, next $d=9874$, then $d=98745$. And if further prosecuted, add Ciphers at pleasure according to the preceding Rules.

$x=\frac{d-pp-bp}{2p+b}+p$, Theorem 1st.

Or $x=\frac{d-\overline{p-b}\times p}{2p+b}+p$, Theor. 2d.

*An Operation according to the first Theorem.*

$8=p^{1st}$

$98=d$
$-64$
$-40$
$-104$
$21)-6.0(-.2$
$+8$
$78=p^{2d}$

$\overline{78}|^2_1=6084=pp$
$4524=bp$
$-10608$
$9174$
$156)-734(-3.4$
$+78$
$746=p^{3d}*$

$*\ \overline{.746}|^2_1=556516$
$437902$
$-994418$
$987459$
$1492)-6459(-3.34$
$+746.00$
$742.66=p^{4th}$

$\overline{742.66}|^2_1=551543.8756$
$435941.42$
$-987485.2256$
$487459$
$207282)-26.2456(-.012689$
$+742.66$
$742.647311=x$ sought.

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II. *EXAMPLE.*

*PUT* $xxx-2x=5$, or $xxx-bx=c$.

Here's no need of any Puuctations in this Example.

Theorem $x=\frac{c+bp-p^3}{3pp-b}+p$

$2=p^{1st}$

$5=c$
$4$
$9$
$-8=p^3$
$18)1.0(.1$
$+2$
$2.1=p^{2d}$

$5=c$
$4.2$
$4.2$
$-9.261=p^3$
$11.23)-.061(-.0054$
$+2.1$
$2.0946=p^{3d}*$

$*\ 5=c$
$4.1892$
$9.1892=bp+c$
$-9.18741550536=p^3$
$11.16205)-.00054155053 6(-.000048517$
$+2.0946$
$2.094551483=x$, sought.

## III. *EXAMPLE.*

$$xxx + 74xx + 8729x = 560783$$
$$xxx + bxx + cx = d$$

(1) $x^3 + 7x^2 + 87x = 560.$ (2) $x^3 + 74x^2 + 8729x = 560783$

(1) $b = 7.$ (2) $b = 74.$ 1. Theor. $x = \frac{d - p^3 - bp^2 - cp}{c + 3p^3 + 2bp} + p.$

(1) $c = 87.$ (2) $c = 8729.$

(1) $d = 570.$ (2) $d = 560783.$ 2. Theor. $x = \frac{d - p^2 - bp \times c}{c + 3p + 2b \times p} + p.$

*An Operation according to the second Theorem.*

$4 = p^{1st}$
$116 = pp$
$128 = pp$
$187 = cp$
$-131$ Total
$4 = p$
$-524$
$560 = d$
$191)\,-36\,(-.1$
$+4 = p^{2d}$
$41 = p^{*}$

$*\,41|^2_1 = 1168 = pp$
$13034 = bp$
$18729 = c$
$-13444$ Total.
$41 = p$
$13444$
$53776$
$551204$
$560783 = d$
$19140)\,+9579\,(.48$
$41. = p^{2d}$
$41.48 = p^{3d}$ ☞

☞ $41.48|^2_1 = 11720.5904 = pp$
$13069.52\ . = bp$
$18729\ .\ .\ .\ . = c$
$-13519.1104$
Mult. by $41.48 = p$
Produces $-560772.699392$
$560783 = d$
A $(\ 10.300608$

A $20030)\,10.300608\,(.000514$
$41.48 = p^{3d}$
$41.480514 = x$ sought.

## IV. *EXAMPLE.*

$$-xxxxx + 7xxxx - 20xxx + 155xx = 10000$$
Or, $xxxxx + bxxxx - cxxx + dxx = f.$

Theor. $x = \frac{f - p^5 - cp^3 - bp^4 - dp^2}{-4bp^3 - 2dp - 5p^5 - 3cpp} + p.$

$-5 = p^{1st}$
$-3125 = p^5$
$-2500 = cp^3$
$-4375 = bp^4$
$-3875 = dp^2$
$-13857$
$10000 = f$
$-9765)\,-3875\,(.4$
$-5 = p^{1st}$
$-4.6 = p^{2d}\,*$
$-3500 = 4bp^3$
$-1550 = 2dp$
$-3125 = 5p^5$
$-1500 = 3cpp$
$-9575$ Divisor.

$*\,-2059.62976 = p^5$
$-1946.72 = cp^3$
$-3134.2192 = bp^4$
$-3279.8 = dp^2$
$-10420.36896$
$+10000$
$-7659)\,-420.36896\,(+.055$
$-4.6 = p^{2d}$
$-4.545 - = x$ *propè.*
$-2725.408 = 4bp^3$
$-1426.000 = 2dp$
$-2238.728 = 5p^5$
$-1269.600 = 3cpp$
$-7639.736$ Divisor.

V. *EX-*

V. *EXAMPLE.*

*LET* this Equation be propos'd for the Septisection of an Angle.

$-x^7+cx^5-dx^3+bx=q$

Or, $-x^7+7x^5+14x^3+7x=1.5$  Theor. $x=\dfrac{q+p^7+dp^3-cp^5-bp}{5cp^4+b-7p^6-3dpp}+p$.

$.2=p^{1st}$

$+7.056000=5cp^4+b$
$-1.680448=-7p^6-3dp^2$
$5.375552 \ldots\ldots$)

$+1.6120128=q+p^7+dp^3$
$-1.4022400=-cp^5-bp$
$.2097728$ ( $.03$
$+2$
$.23=p^{2d}$

$.23=p^{2d}$

$+7.09794435=5cp^4+b$
$-2.22283625=-7p^6-3dp^2$
$4.8751081$)

$+1.67037204825447=q+p^7+dp^3$
$-1.6145054401\ldots=-cp^5-bp$
$+.05586660815447$ ( $+.0115$
$+.23$
$.2415=p^{3d}$

$.2415=p^{3d}$

$7.11905196957719$
$-2.45092317574650$
$4.66812879383069$)

$+1.69723543656325544455$
$-1.69625021013057815625$
$+.00098522643267728825$ ( $+.00021105$
$+.2415$

$x$ sought $=$ $.24171105=p^{4th}$

When the Powers arise very high, as in this Example, they are most conveniently manag'd by Logarithms.

To shew the Universality of this Method, and that there's no absolute necessity of Punctations, or taking a Quantity near the Truth, let there be taken a Quantity never so distant from Truth, it will at a few Operations converge to it; which is a great Convenience above all other Methods, in which if you be once out, you must begin again; but in this an Error is but a new Trial, and you are never out of the way, for if you prosecute that Error you will find the Truth, and there is no need of considering the Occasion of it, further than as a Caution for the next Operation. One Example will abundantly evince this.

Let there be propos'd $xx+bx=d$ } Begin as far of Truth as you please.
Or, $xx+5x=646$ } Suppose $p=1$.

Theor. $x=\dfrac{d-pp}{2p+b}+p$ or by Red. $x=\dfrac{d+pp}{2p+b}$

$1=p^{1st}$

646
+1
7) 647 ( $92=p^{2d}$
63
17

92
92
184
828
+8464
646
189) 9110 ( $48=p^{3d}$
756
1550

48
48
384
192
2304
646
101) 2950 ( $29=p^{4th}$
202
930

$29=p^{4th}$
29
261
58
841
646
63) 1487 ( $23=p^{5th}$
126
227

23
23
69
46
529
646
51) 1175 ( $23.03=p^{6th}=x$ sought.
102
155
153
200

These

These Examples I have borrowed out of Mr. *Raphson*, where such as please may see great Variety: But his Method is so natural, easy, and yet general, that half of these Examples would have given a very dull Reader sufficient Instruction in all Cases that can happen, as well as a particular Satisfaction in partaking the Benefits of such an happy Discovery, which no doubt but future Ages will very gratefully acknowledg.

*F I N I S.*

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*ERRATA.*

Page 1. §. 7. line 2. in *Compounds*, expunge *s*.
Pag. 2. Parag. I. line 4. for $3da$, read $13da$.
Idem. Parag. IV. l. 7. for *s*, read *ss*.
Pag. 3. Parag. 4. l. *ult.* for $-a^3$, read $-3a^3$.
Pag. 4. Parag. 3. l. 11. for $-c^3bd$, read $+c^3bd$.
Idem. l. 12. for $+cb$, read $bb$, and for $-c^3bd$, read $+c^3bd$.
Pag. 6. L. 1. l. 3. expunge *Coroll. id.* and prefix it to *Lemma* II.
Idem. §. III. l. 2. betwixt *therefore* and *divide*, insert *actually*.
Idem. §. V. l. *penult.* for $d+e$, read $dd+e$.
Pag. 7. §. VII. l. 6. betwixt *ac* and *bb*, insert a Point.
Idem. §. VIII. l. 6. for *h* twice, read *b* twice.
Pag. 8. Parag. *ult.* l. 9. for *aatn*, read *aaatn*.
Idem. §. II. l. *ult.* for *bcddr*, read *6cddr*.
Pag. 10. In the Line expressing the Root, for *a* & *b*, read *b* & *a*.
Idem. In the Figure of the Cube, for *aa* mend *aab*, and in the next Cell underneath write *bba*.
Idem. In the Figure of the Biquadrate, mend *Biquadr.*
Idem. §. IV. *ult.* for *quadratim*, read *gradatim*.
Pag. 11. l. 1. for $\overline{2612}|\frac{2}{7}$, read $\overline{6212}|\frac{2}{7}$.
Idem. §. V. l. 6. betwixt *have* and *Ciphers*, insert *five*.
Idem. §. VI. l. 6. instead of $2ab$, read $2a)2ab$, &c.
Idem. Parag. 1. l. 1. expunge *the*.
Pag. 12. l. 26. for 3357, read 3375.
Idem. §. VII. l. 7. expunge *Squared* after *which*, and insert it after *Quote*.
Pag. 14. §. IX. l. 18, 19, 20, expunge wholy.
Pag. 15. Parag. 2. l. 3. set 8 one place nearer to the right hand.
Pag. 17. l. *penult*, for $qq-10$, read $qq+10$.
Idem. l. *ult.* for $qq-100$, read $qq-10$.
Pag. 18. In Division, the second Line, for $-10$, read $+10$.
Pag. 19. l. 3. for $+bx$, read $-bx$.
Pag. 22. *Quest.* 8. l. *ult.* instead of $aa-xx$, read $aa=aa-xx$, or, &c.
Pag. 23. *Quest.* 13. the Quest. is Universal for all Triangles whatever.
Idem. *Quest.* 14. after *four*, read *or*.
Pag. 26. l. 1. expunge *ly* in *immediately*.
Pag. 27. §. 4. l. 16 & 21. instead of $\sqrt{\frac{cc}{4d}}$, read $\sqrt{\frac{cc}{\frac{1}{4}d}}$.
Pag. 29. Parag. 3. l. *ult.* for *imaginary Equation*, read *impracticable Equation*.
Pag. 30. Parag. 3. l. 2. for *imaginary or impossible*, read *impracticable Equation*.
Pag. 33. *Q.* 1. l. 28. for $\sqrt{\frac{625}{16}}$ read $\sqrt{\frac{625}{16}}$.
Pag. 35. *Q.* 1. l. 8. for $cc+aa-bb$, read $cc+bb-aa$.
Pag. 36. *Q.* 2. l. 3. for CE and AB, read AE and DE.
Idem. l. 16. instead of $\sqrt{aa+a}\left.\begin{matrix}+ll\\ \end{matrix}\right\}$ read $\sqrt{aa+ll}\left.\begin{matrix}\\ +a\end{matrix}\right\}$
Pag. 39. in the Title expunge *Quadratic*, &c.
Idem. in the last line but two, expunge *Biquadratic and higher*.
Pag. 40. in the Title, expunge *Biquadratic*, &c.
Pag. 41. l. 5 and 9. for lesser, read less.